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THE SEA-SIDE ZOOLOGICAL LABORATORY AT NAPLES.

SOME fifteen or twenty years ago, when a naturalist found it necessary, in order to resolve a problem, to have recourse to a certain marine species, it cost him much trouble and money. He was obliged to find out the station where the desired species was to be found, and which was often very distant from his residence; and then, having gone there, he had to look up a boat and fishermen, locate himself in some inconvenient hotel, and there, alone, without other resources than those due to his own devising, he passed weeks, and often months, in fruitless endeavors, losing time for want of a library, interrupted in his operations by need of reagents, and often returning home no wiser than when he left it, very much out of sorts with an unexpectedly unpropitious season, or some other *contretemps* which had not allowed him to gather the material desired. Moreover, the good fortune to be able to visit the sea shore was within the reach of a few only; the young investigator or the student with a light purse could not even think of such a thing in the majority of cases. But to-day, thanks to the initiative of a few eminent men, things have greatly changed in this respect, for there have now been established on the coasts of most seas permanent laboratories. The founders of these, adding to their own personal experience that of numerous sea coast explorers, have located them where the maritime fauna is at once most abundant and varied. They have brought together in special apartments all that can prove useful to the zoologist—microscopes, dissecting apparatus, aquaria, special libraries, etc. Here they create, so to speak, fishermen to search for the lower animals; teach them to distinguish the larger groups, then the genera, and even the species, and to note the usual habitat of these; to make out lists of the most common objects, and to point out those which are rare, etc. They purchase row boats, sail boats, steamboats, sounding and dredging apparatus, and then invite scientists of all countries, some gratuitously and others at a certain fee, to come and take advantage of this wealth of material and of these conveniences. Seaside researches, which were formerly the privilege of a few, have in this way been put within the reach of all. The student now travels with certainty, sure beforehand of finding material already prepared for him, so to speak, and an assemblage of highly instructed individuals. The service rendered zoology thereby is immense, and to convince ourselves of the fact it will be only necessary to turn over the pages of some of the scientific journals in which are recorded the researches made in these laboratories. Let us open, for example, the "Archives of Experimental Zoology," of M. de Lacaze Duthier, the celebrated founder of the Roscoff Laboratory (Finistère), or the *Mittheilungen* of the Naples station, of which we are about to speak, and we shall see what original memoirs and what important finds have been made at these stations. It would be trite at the present day to dwell at too great a length on the importance of the lower animals in zoological studies. We have been accustomed to see them playing a *role* of prime importance in modern theories, and, in fact, it is these elementary organizers which allow us to obtain the deepest insight into the beginnings of life. The magnificent works of our own age—those which serve as a base to biological philosophy, owe much to a knowledge of these beings. On another hand the sea is an indefatigable nurse—all branches of zoology are represented therein, from the monad up to the mammal, and the amount of animals found there is excessive, offering at all times an immense amount of material, the study of which has become an indispensable complement to the education of a naturalist. For this reason it may be said that, if zoological stations *are* of the greatest aid to scientists who are pursuing original researches, they are of incalculable benefit also to the young man who comes to them for the first time to contemplate the marvelous riches of the sea. Zoological stations, or simple laboratories, are to be found on the Atlantic, the English Channel, the North Sea, the Adriatic, the Mediterranean, etc. We believe that we will interest the reader in giving an account of the most extensive and richest of these stations—the one founded at Naples some years ago by an eminent naturalist, Prof. Dohrn.

The choosing of Naples for the establishment of a zoological station is easily explained. Its gulf is one of the richest known, especially in pelagic animals. Thanks to the descriptive work undertaken at this station, and to which we shall advert further on, the list of Neapolitan species is daily increasing. On another hand, the Neapolitans, who are essentially a fishing people, are able to furnish useful information, and the station has managed to make them a valuable auxiliary. The nets of the fishermen bring up not only representatives of that class in which Count Marsigli enters all *edible fishes*, in contradistinction to those that are *not edible*, but their meshes secure animals of all sorts, and those *frutti di mare* of all species which figure in the stalls of Santa Lucia. It was advantageous, consequently, to locate the station in the vicinity of the city, in order that the fishermen might bring thither these extra products of their hauls; and from this point of view experience has fully confirmed expectations. M. Dohrn, the founder of the station, ably conceived a plan (which, moreover, has been put in execution) of joining to the purely scientific part of the establishment, whose resources offer themselves to scientists alone, a large aquarium which should be apt to attract the curiosity of the public, and in that way popularize a study which is day by day assuming a greater importance. Nothing better could have been conceived than placing this aquarium in a city whose celebrated sights yearly attract a large number of foreigners. It is true that in this respect the expectations of the director have been far from being realized. He had thought that the receipts resulting from prices of admission to the aquarium (1 franc in summer, and 2 francs in winter) would be sufficient to support the scientific station, but the number of visitors was found to be not so great as there was reason to expect (the unequaled riches of the aquarium being taken into consideration), and on another hand, the expenses necessitated in keeping it up exceeded calculations. However, even if the financial object has not been attained, the fact must be recognized that

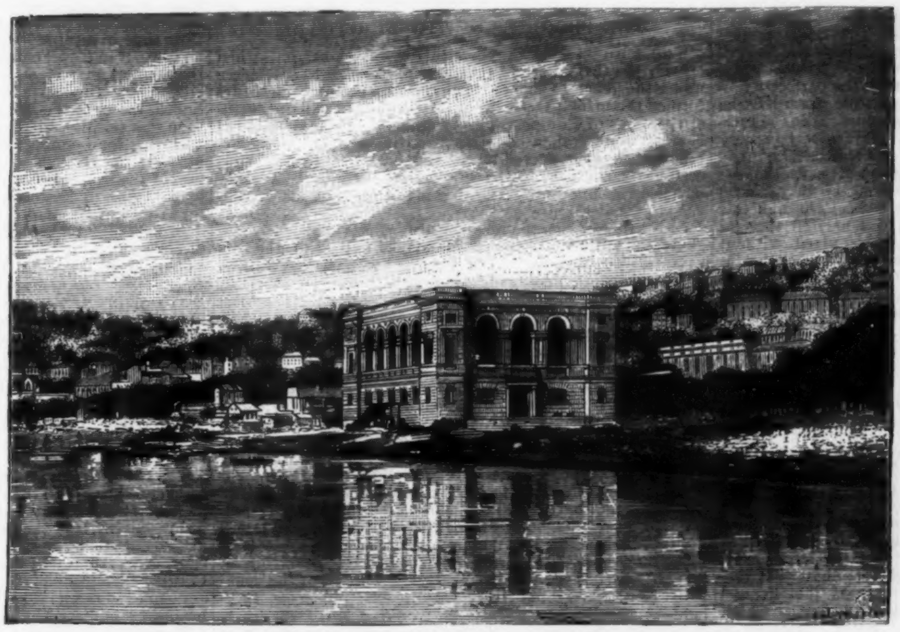


FIG. 1.—THE MARITIME ZOOLOGICAL STATION AT NAPLES.

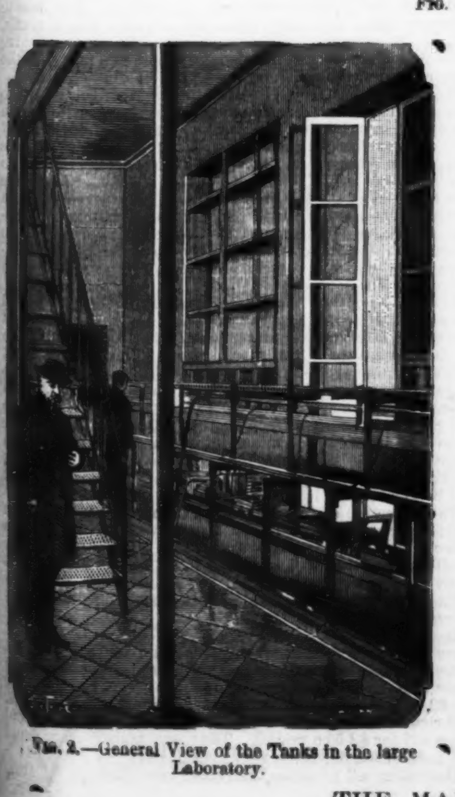


FIG. 2.—General View of the Tanks in the large Laboratory.

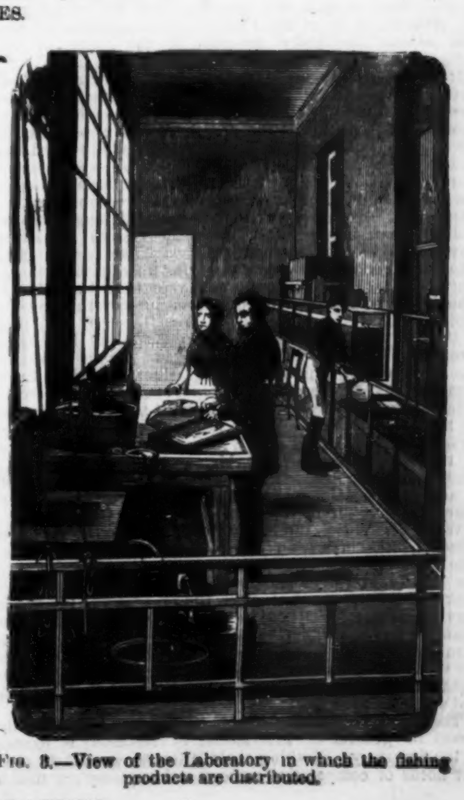


FIG. 3.—View of the Laboratory in which the fishing products are distributed.

THE MARINE ZOOLOGICAL INSTITUTION AT NAPLES.

the Naples aquarium stands in the front rank of the curiosities of a city which is already rich in this respect.

The beautiful rectangular building (Fig. 1) erected at great expense by Prof. Dohrn is along the Via Nazionale, the most beautiful promenade of Naples, and in the immediate vicinity of the sea. We shall not enter into the details of the difficulties of all kinds that the eminent naturalist had to surmount. After hundreds of conferences, he obtained from the municipality of Naples a cession of a piece of land of 704 square meters, on condition that after thirty years the entire station should become the property of the city; but a later contract extended the duration of the cession to ninety years, after which time Naples will be owner of the establishment. A special clause, moreover, guarantees the direction of it for all time to Prof. Dohrn's family. The building is solidly constructed, and the elegance of its architecture makes it resemble a palace. A wide, main entrance leads to the aquarium, which is located nearly on a level with the external ground. A vast hall, covering a space of 260 square meters, contains, against the walls on three of the sides, immense tanks of various dimensions, in which are moving about, as if in their native seas, representatives of all zoological groups. Analogous tanks are arranged according to a rectangle in the center of the hall, in such a way that, taken as a whole, they represent a veritable sea on a small scale. They contain, in fact, no less than 440 cubic meters of water. The largest of them, situated to the west, alone contains 112 cubic meters, and it is in this that the large fish, such as *Scyllum*, *Serranus*, etc., disport. To the south, eleven tanks, containing together 160 cubic meters, face the tanks to the north, which contain 135 cubic meters. Finally, the central tanks contain only about 35 cubic meters, and these harbor certain Crustaceans, Annelids, Crinoids, Cœlentera, etc.

The piping which leads the water into these different tanks is a *chef d'œuvre* in its construction. We cannot give a description of it in this place, but this may be found in Prof. Dohrn's report, printed in the first volume of the *Mittheilungen*. We will simply say, in order to give some idea of the importance of it, that it discharges into the different tanks every hour a volume of water equal to 10 cubic meters, and that every precaution has been taken to guard against the accidents inherent to such a circulation of liquid. The water is drawn directly from the sea during calm weather, by means of a pump on the California system, constructed in Germany, and worked by a four-horse power horizontal steam engine. The water is first led into the basement of the building, where it remains for eight or ten days in three vast cisterns of about 500 cubic meters capacity. This is necessary, in order to allow the impurities to subside, and to give it the requisite transparency. From these cisterns different pumps raise the perfectly limpid and clear water up to the upper reservoir, from whence it is distributed into each tank. All the pipes, as in the English aquaria, are made of hard rubber. This material is very costly, it is true, but it is very strong, and has the advantage that it does not undergo alteration in contact with the sea water, which, as may be readily conceived, is an essential condition to the well-being of the animals. Through this abundant circulation the water is so well aerated, that (as shown by experience) the flow may be stopped without detriment to the animals for a period of twelve hours in winter and six in summer. It suffices of itself for the respiration of the animals, without the necessity of recourse to such means as aeration, etc., as are employed in other aquaria—that of Berlin, for example. This is the reason of the good health of the animals that live in the large aquarium, as well as of those which, under the observation of the scientists of the station, are kept in special tanks that we shall speak of further on. Indeed, as regards this excellent health of the animals kept in its tanks, the station has had an unprecedented success. To be convinced of this it is only necessary to read in the *Mittheilungen* the reports of Mr. R. Schmidtlein, who has the chief direction of this part of the establishment. Thus, in the tank devoted to poulpes (*Octopus vulgaris*), there is one individual of very beautiful form, which has been living therein for three years; and fishes are preserved in the tanks for many months, as are also the larger crustaceans. But it is not only the higher animals that disport themselves and multiply therein, as if "at home," but also those puny, delicate, transparent beings which occupy the lower scale in the animal world. Nothing is at once more elegant and graceful than the swaying of the *Rhizostomes*, or of the *Pelagiæ*, the undulations of *Cestum veneris*, the jerky progress of the *Salpæ*, or the "flight" of certain Pteropoda.

It will be readily understood what a prize, outside of all anatomical considerations, such an establishment must be for every naturalist who desires to gain an insight into the habits of the animals of the deep. We have said that all the large zoological groups are represented here; indeed, the wealth of this establishment in different families and genera is truly unequaled by any other. To learn the affinities in the character of all these animals, so as to bring together friends and separate enemies, has required long years of study. From this point of view, the Naples Aquarium leaves nothing to be desired. Although we cannot enter into any details—since we are giving merely the general features of the establishment—we may state that the objects which most attract the curiosity of visitors are the tanks of tubicolous Annelids, Crinoids, Corals, Gorgons, etc.; that of the Hydromedusæ and those of the Echinoids, large Gasteropods, Poulpes, Sepias, and Loligos. Mr. Schmidtlein has published a "Guide to the Aquarium," in which there is given a description of the principal species found here.

In two small tanks, which are isolated and placed so as to be more directly accessible to visitors, there are always to be found hidden in the sand a few specimens of the lowest of the vertebrates—the *Amphioxus*, or the "Venerable" Amphioxus, as one of our most famous zoologists has called it, and also a specimen of the Torpedo, whose electrical discharge gives rise to both pleasure and fear in everybody.

When one enters the aquarium he is from the very first struck by the mysterious darkness which reigns therein. The cause of this, which, however, is only relative, lies in the fact that light enters the hall only through the large tank, which it in the first place illumines. The lighting is very good, very equal, and is not one of the least of the causes of the fine state in which the animals are kept. It is furnished by nineteen lateral windows (which may be opened for ventilation), and by a large open space which allows the light from the upper part of the building to fall on the central aquaria.

The zoological station proper so called (that is, the group in general of laboratories of research) is located in the first story. Nothing could better show what the present needs of comparative zoology and anatomy are than a visit to this establishment, which stands at the head of the principal zoological institutions of Europe. The entrance to it is by means of a wide stairway to the right of the main vestibule, and from thence access is easy to all the different apartments. The largest of the rooms—the "Great Laboratory"—occupies the north end of the building and is 25 feet high (Fig. 2). It is divided into two stories by a horizontal platform, which is reached by means of an iron staircase. In the lateral galleries of this platform is kept the scientific collection, which is already very large and which is increasing in value every day. In the hall below are found the tables for the use of naturalists, and which are located in the vicinity of large windows. Thus they receive a good light, which is so necessary in microscopical investigations, and they are also provided with all the reagents employed in technical work. In the back part of the room is located a long tank, which is at the disposal of workers; and, in addition thereto, there are an infinite number of small aquaria, basins, etc., which permit each one to follow, minute by minute, so to speak, the development of any particular animal. It is in this and the adjacent halls that the important labors have been performed. To the right hand, on coming out, we find another hall, likewise filled with aquaria, and which is more particularly designed for the sorting of the products of fishing (Fig. 3). It is here that is stationed the employe whose duty it is to bargain directly with the Neapolitan fishermen, who come every day to offer such zoological curiosities as are caught in their nets. Afterwards he has to sort out the specimens and send to the scientists the material necessary for their researches. This hall is also much frequented by naturalists, who are almost always certain of meeting with some new surprise there, either in the shape of a rare species, a monstrosity, or some singular case of parasitism, etc. The room presents an animated scene at times, especially on the return of sounding or dredging expeditions, when each one empties his pails and bottles, and separates, distributes, or puts one side the specimens that he desires to preserve and those that he is preparing to study. There is found in this hall, likewise, a large table on which the dissection of large specimens (cetaceans, fishes, etc.) is performed. Finally, in each wing of the building there are located special workrooms, which are occupied by the scientific assistants attached to the station. In each of these there are work-tables, analogous to those before-mentioned, and the material necessary for the special researches of each assistant.—*Emile Yung, in La Nature.*

THE PROGRESS OF THE FUR TRADE.

THE term "fur" is applied to dressed skins, but when taken from the animals' backs they are known to commerce under the general name of "peltry." In the early ages furs formed the principal wealth of the people of the more northern sections of Europe. They were used in commercial exchanges with other countries, and in payment of debts. Siberia, when conquered by the Russians, about three hundred years ago, paid its tribute in furs. Russia is a great purchaser of fine furs. The wearing of these goods is universal in that Empire.

In North America the lucrativeness of this trade early engaged the attention of the merchants, as well as of the adventurers of Europe. The French, who settled in the northern section about the year 1640, began to establish trading posts around the Red River, and the efforts of the English nation to dispossess them and control the fur trade, led to the early French and Indian wars on this continent, which resulted in the annexation of the far northern country to the possessions of the English Crown.

In 1670 Charles II., of England, granted a charter to Prince Rupert, the Duke of Albemarle, Earl Craven, Lord Ashley, and others, ceding to them an area of country of about 4,500,000 square miles, in the extreme northern portion of North America. This section of land is as large as the Continent of Europe. It was then called Rupert's Land. They afterward took the name of the Hudson's Bay Company, and have held possession and traded in this country since that time. They have always discouraged immigration, their policy being simply to keep the domain as a vast preserve for fur-bearing animals. The tract is inhabited only by Indians and the agents and servants of the company. Ships freighted with goods are sent out from England at regular periods, and it would seem from their cargoes that the wants of the red men were the same as they were a hundred or more years ago. Cotton, cloth, rum, cheap ornaments, firearms and ammunition, form the import, and furs are the return cargo. These are sold at public auction at the Hudson Bay House, in Lime street, London, at regular periods, and merchants from every part of Europe are purchasers. The sales of the company aggregate some $6,500,000 yearly.

Until some fifteen or twenty years ago these auction sales in London were conducted "by inch of candle." A pin was stuck into a lighted candle; the bidding was continued until the pin fell in consequence of the approach of the flame, and the highest bidder before the fall of the pin was declared the purchaser.

In 1783 a combination of fur traders was made in Canada, under the name of "The North-Western Company of Montreal." There were twenty-three shareholders, comprising the most wealthy residents of the Canadian capital, and for many years they held lordly sway over the vast forests and rivers of Upper Canada. They were mostly of Scotch descent, and for about half a century these "North-Westers," as they were called, were monarchs among the fur traders. They employed 5,000 men—trappers, guides, clerks, agents, and others. The profits of the business were enormous, but the rivalry and hostility of the two companies were such that the operations of both were impeded, and their prosperity interrupted. In 1821 a union was formed, and the trade has since been steadily and successfully conducted, under the name of the Hudson's Bay Company. Their charter expired, and the country became part of the Dominion of Canada, July 15, 1870. The company retain possession of their posts and adjoining lands, and were paid £300,000 for their franchises. Their capital stock is now $10,000,000.

The method of trading for furs has varied but little since the organization of the company. The Indians bring in the peltry during the winter months, and camp outside the trading posts. Only one or two are allowed inside at one time. The furs are weighed, and a number of little sticks, representing a certain value, are given for them. The owners are then admitted to the store-house, one at a time, where they select what they want and give up the required number of sticks with each article purchased, until their stock of vouchers is exhausted.

The commercial interest awakened by the fur trade led to the early settlement of the western section of the United States. An association called the Mackinaw Company had been formed by British merchants, and they traded from Green Bay, down the Wisconsin, to the Mississippi River. In 1763 an organization of New Orleans merchants was formed for the purpose of trading in furs.

This company, incorporated under the name of "The Missouri Fur Company," was projected by Pierre Laclede, who, in connection with Auguste and Pierre Choteau, made a settlement at St. Louis, and the place became a trading post and populous town at a time when nearly all the rest of the country, from the Atlantic seaboard to the Mississippi River, was a wilderness. The company established trading posts at the forks of the Missouri and throughout the Indian nations, giving employment to several hundred men. The headquarters of these, together with the boatmen who took the cargoes down the Mississippi River and brought back supplies, being at St. Louis, made this quite an important town in the early part of the present century. It is estimated that from the years 1800 to 1830 the fur trade of St. Louis was about $300,000 a year, and for twenty years after that it amounted to at least $500,000 a year. Martin Bates & Co., of New York, succeeded to the business of the Missouri Fur Company, and still continue it.

We stated in the commencement of this article that nations in early times canceled their indebtedness with furs. If we may believe the words of an old campaign ditty, that course was formerly adopted by one of our own States. The verse in the song alluded to runs as follows:

"General Jackson, who is he?
They say he comes from Tennessee;
But Tennessee is no great things,
She pays her debts in raccoon skins."

Up to about the year 1830 the fur trade was exceedingly profitable and of vast extent. In the United States alone about six millions of peltry of all kinds were gathered yearly, their value being from fifteen cents to five hundred dollars each. Every respectable man in Europe or America wore a beaver hat upon his head. Good beaver skins were procured in any quantity from the Indians for a few shillings' worth of merchandise or rum for each skin, and these could be sold in New York for two to four dollars, and for nearly double that sum in London. It was probably considerations like these which induced the man who rose to be the greatest of American fur merchants to embark in the business during the later years of the last century.

John Jacob Astor came from Germany to this country in 1784. His entire worldly possessions were seven German flutes, which, following the advice of a countryman who came over with him, he exchanged for furs. He worked a little time in a fur store in New York to learn the business, and began to travel on his own account in New York State, then almost an unbroken wilderness. He traded with the Indians for furs. He had at that time as partner Peter Smith, father of the late well-known Gerrit Smith. He was soon in a position to purchase a vessel, which was loaded with furs for London, and he occasionally made the voyage himself. In London he learned of the extreme lucrativeness of the trade with China, and about the year 1800 sent his first ship to Canton with furs, for which she took a return cargo of teas and other goods.

In 1809 Mr. Astor obtained from the New York Legislature a charter for "The American Fur Company," with a capital of $1,000,000. This capital he furnished himself, and entered into articles of agreement with a few practical men to found a colony at the mouth of the Columbia River, in Oregon, for the purpose of trading in furs. Wilson Price Hunt, of Trenton, N. J., and Ramsay Crooks, a young Scotchman who had been in the employ of the North-West Company, were the principal parties to the agreement, and they conducted an expedition across the Rocky Mountains, and founded what is now known as Astoria. The object was to establish a trade with China. A full history of this enterprise has been given by Washington Irving in his book called "Astoria."

The breaking out of the war of 1812 put a stop to the Astoria enterprise, and the American Fur Company transferred its field of operations east of the Rocky Mountains. Mr. Astor, having laid the foundation of the greatest fortune ever accumulated at that time in America, retired from the fur business, and was succeeded by Ramsay Crooks, who, in turn, gave place to Wm. Macnaughtan, whose son, Ramsay Macnaughtan, still continues, in Howard street, the business established by John Jacob Astor in 1784.

Furs are gathered in cold weather, brought to market and sold in the early spring and summer months. The manufacturers make up their stock of circulars, capes, muffs, etc., in the autumn, and the goods are sold and worn to give warmth and comfort to members of the human family in the ensuing winter season.

Most of the furs from North America which are sent to Europe are disposed of at auction. The great sales are in the spring months, and as many as a million of one kind of skin are sometimes disposed of at a single sale. Sales are also held in January and July. We have already alluded to the Hudson's Bay Company's public auction. There are also the sales of C. M. Lampson & Co., which rival them in extent. The head of this house, Sir Curtis Miranda Lampson, is a native of Vermont. He has been knighted by the Queen, was for some years Deputy-Governor of the Hudson's Bay Company, and conducts the largest fur house in Europe.

Leipsic, Germany, is the headquarters of the continental fur trade. Heinrich Lomer has in that city the largest and one of the oldest fur auction houses on the continent, which has been established for many years. Three other great public auctions are held there yearly of furs from all parts of North America. These sales are conducted by Joseph Ullmann, an American merchant well-known in Chicago and St. Paul as a great fur operator. He has houses there as well as in New York, and established the business in Leipsic in 1875. The most important sale transpires during the Easter fair at Leipsic, and there are also sales in January and September.

The collection of furs for the winter of 1880-81 has been short on account of the unusual quantity of snow which has fallen. It is anticipated, however, that the supply will be a full one, but they will come in later, and prices are not likely to advance.

The principal merchantable North American skins are as follows.

Beaver skins, which are exported and sold to all countries. They are largely used for dyeing, plucking, and coloring, and in that manner much additional value is given, and they are made into cloak trimmings. Good beaver skins sell here for $2 to $2.50 a pound, but there are some skins so dark and rich in color that they are made up "in the hair," and these sell for $3.50 a pound. They are higher than usual the present season, being very fashionable.

Bear skins sell for robes, and small bear skins go to Rus-

sia, where they are made into coats. They are worth here $10 to $15 each.

Wild cat are used for robes and linings here and in Europe.

Fisher skins are gathered in Canada, the Lake Superior region, and Pacific coast. They are largely sold to go to Russia, where they are made into coats and collars. A dark-cased fisher skin sells for $9 to $12, and will bring at auction in Europe $10 to $14.

Fox skins are being used this season by the American trade, but at least three-quarters of them go to Russia and Turkey, the latter place taking the poor grades. Red fox are worth $1.50 to $2, and this is the skin which sells in Turkey; gray fox $1, but the silver fox sells at $25 to $50 each skin.

Lynx skins sell for the European markets, where many of them are dyed and then reimported. They are worth here $2 to $3 each.

Marten is a fine fur. The dark skins are used for trimmings and the pale skins for cloak linings. Marten skins sell at from $2.50 to $5 each.

Mink skins are held at far less value than formerly, but they sell in Europe for linings for coats. The best are worth here $1 to $2.25 each.

Muskrat sell here at 10c. to 20c. each. They are about the only skins we dye in this country, and many are used here for cloaks and trimmings. Over 700,000 are used yearly in that manner. They are also sold to Russia and Germany, and used for linings, cuffs, and collars.

Otter have increased very materially in value lately, as they are dyed and plucked, and sold as an imitation of sealskin. Three-quarters of the skins gathered sell in this country. Good skins are worth $5 to $10 each.

Sea otter is a very valuable fur, worth say $100 each. They are used for trimmings by the nobility of the Continent of Europe.

The seal skin has been for the past ten years one of the most fashionable of furs. They are the pelt of the fur seal, principally found on two islands of Alaska, one of which, St. Paul, is said to be visited annually by more than five millions of fur seals. These islands, as well as the mainland of Alaski, were discovered by the Russians about 1741, and in 1786 were colonized by the Russian-American Fur Company, who carried on operations there up to the time of the transfer of the country to the United States, which occurred in 1867.

In 1870 a lease of the seal islands was granted by the United States to the Alaska commercial company, of San Francisco, for the term of twenty years, under certain restrictions and conditions. They are only allowed to kill 100,000 seals a year, and these must be males. Upon the skins they pay a tax of $2.50 per pelt, with a bonus of $50,000, making a revenue of $300,000 yearly. There are two hundred and seventy inhabitants in these islands, and they are, by the terms of the lease, permitted to reside there to the exclusion of all others, and are alone allowed to participate in the labors and rewards of the seal traffic. They get forty cents a skin, and take off the whole hundred thousand in about thirty days, averaging to make about $400 for each working man. They can take a hide off neatly in from two to four minutes.

The skins are piled with the flesh side uppermost, and each profusely sprinkled with salt. After lying in this pickle a week they are bundled up and shipped to San Francisco, and from thence to London, where they are dressed.

The coat of the seal, when ready for sale, is fine and soft, but this is really only an undergrowth, as a coat of long, coarse over-hair has first to be plucked off, which is done by heating the skin, and then the long hair is plucked out, leaving the fine elastic under-fur, which is dyed or painted several times with a solution made chiefly of nuts from the Grecian Archipelago, after which they are cleansed from all impurities, stretched to their fullest capacity, and left to dry. Then all the long hairs are carefully clipped off with scissors, and the skin is ready for the furrier. Some of these skins are finished in this country, but not a great many. There is a company in London who do the most of it, and the preparation and application of the dye is a very fine art.

Sealskins sell according to length and fineness. A skin 29 or 30 inches long sells for $10 raw, and $25 dyed and dressed. The longest skins, say 51 inches, sell raw for $15 to $20, and dressed for $50 each. For a lady's sack of ordinary dimensions it takes three to three and a half skins, and for a dolman four skins to each garment.

Coon skins go to Europe in large quantities, being used in natural state or dyed in all parts of that continent. Good coon skins are worth 60c. to $1.10 each.

Rabbit skins are used by hatters. These go to Europe from all quarters of the world, and 12,000,000 skins were imported into London in 1880. The skins are worth about 50c. to $1 a dozen in London. Large quantities come here; they are classed as hatters' furs.

Skunk skins go to Europe, and find sale all over that continent. Good cased skins sell in New York at 75c. to $1.25, and in London some twenty-five per cent. higher. These skins are graded long stripe, short stripe, and black, the last the most valuable, and they are used in natural color.

Wolf skins are used for robes, but have lost value lately from the fact that China goatskins have taken their place to some extent.

Wolverine skins go to Europe, and are also used here for robes.

Furs in the cold countries of Europe are prized as diamonds are with us.

All furs, but coon, wolf, beaver, and seal, should be taken off "cased;" to do this a small slit is cut in the stern and the skin worked off by turning it inside out. The European manufacturers like the cased skins, as they can cut them up at each side, and then have either back or belly to line cloaks with as preferred, the finer cloaks, of coarse, taking the best portions of the skin.

After the skins are sent to market they have to be beamed to get off all the fat. Nearly all kinds are dyed, as fashion dictates that everything in this line must be dark in hue.

Fine furs are dressed by being placed in tubs together with a quantity of rancid butter, and are then trampled upon by the feet of men. The pelt thus becomes softened, as though partially tanned. They are then cleaned by rubbing them with a strip of iron, and the grease removed by trampling again with sawdust mixture, beating them out and combing the fur. This is about all that is necessary to prepare them for the cutter and manufacturer.

Glovers' stocks are distinct from peltries, and used for making gloves. They are antelope, deer, elk, and mountain deer, worth in the Eastern markets 35c. to 45c. a pound. They are nearly all sold to Gloversville and Johnstown manufacturers. In the above towns, where more than three hundred firms are engaged in glove dressing and manufacturing, much of the glove stock which comes from both North and South America is made up. The business amounts to from $6,000,000 to $7,000,000 a year.

The skins are tanned or tawed for gloves, as follows: If hard stock they are first broken or softened, and placed in lime water to remove the hair. They are then thoroughly worked in pure water to remove the lime and render them flexible. They are now placed in a fulling mill in the shape of a box with two iron hammers working by cranks, which play on the skins and soften them. While going through this process cod oil is poured on, and the skins thus prepared are known as oil-dressed stock. They are now taken out and dried again, after which they are placed in vats containing lime water and soda ash, in order to cut the oil left on the skins by the former process. They are then scoured out and hung up outdoors to bleach, when they come out very white. The skins are then held to an emery rotary wheel and the face finished.

The official statement of exports and imports of furs, as given by the U. S. Treasury Department, we give below. It will enable our readers to form an idea of the extent of the business:

IMPORTS, 1880.	
Fur skins, undressed	$2,543,728
Furs, dressed	4,185,392
Total	$6,729,120
EXPORTS, 1880.	
Furs, undressed	$5,542,735
IMPORTS, 1879.	
Fur skins, undressed	$2,131,196
Furs, dressed	3,054,699
Total	$5,185,895
EXPORTS, 1879.	
Furs, undressed	$6,086,829
IMPORTS, 1878.	
Fur skins, undressed	$1,454,653
Furs, dressed	2,560,684
Total	$4,015,337
EXPORTS, 1878.	
Furs, undressed	$2,941,602
IMPORTS, 1877.	
Fur skins, undressed	$1,613,839
Furs, dressed	2,157,349
Total	$3,771,188
EXPORTS, 1877.	
Furs, undressed	$3,709,016
IMPORTS, 1876.	
Fur skins, undressed	$1,442,752
Furs, dressed	2,610,950
Total	$4,053,702
EXPORTS, 1876.	
Furs, undressed	$3,750,648

The duty on manufactured furs is 35 per cent., less 10 per cent. For furs dressed on the skin and hatters' furs it is 20 per cent., and raw furs are admitted free of duty. It will be noticed by the above table that the import value of furs is larger than the export. The truth is, that a very large proportion of the article of "furs dressed" is a reimportation of American furs which go to Europe for dyeing and plucking, and are then returned here. We send abroad, for instance, 100,000 sealskins yearly, and nearly every garment made from that material and worn in the United States is from reimported skins which have had to pay duty, freight, and profit on the labor expended on them by European experts.

It does not speak well for the efficiency or genius of the American workmen that these raw goods have to go to Europe and be finished there ready for wearing. Then, again, the duty is a severe tax on so fashionable and necessary an article as fur. The subject of dressing and finishing peltries is beginning to engage the attention of manufacturers, and, doubtless, this branch will soon be added to the list of our home industries.—*Shoe and Leather Reporter.*

MICHEL CHASLES.

BY the death of M. Chasles, to which we referred in a previous number, modern geometry has lost one of its most ardent and successful cultivators. For more than half a century numerous students, and even distinguished professors of his own and of other countries, eagerly gathered round his chair to listen to his exposition of methods which he himself had invented or considerably developed. Sixty-eight years separate his first mathematical paper from his last communication to the Academy of Sciences, and that long period was one of singular devotion to his favorite pursuits.

The influence of his teaching was great and far reaching. Many of his beautiful theorems have found their way into text-books used in higher collegiate classes, while his more elaborate researches are carefully read in our universities. He was emphatically an original investigator, and may, without detracting from the merit of his predecessors, be styled the Father of Modern Geometry.

M. Chasles was born at Eperon, near Chartres, in November, 1793, and from his early youth showed unusual mathematical talent. His fondness for geometry recalled the passionate devotedness of the brilliant Pascal. At the Lycée Impérial his usual pastime was to explain the difficulties of his class-mates, and work out the more knotty riders given in other schools. Many of his solutions, we are told by those who knew the young mathematician, were remarkably beautiful, and even the great Poncelet more than once publicly commended their ingenuity. Chasles used to call these exercises his "elementaires," and he was never more cheerful than when he had a good supply by him. It is significant that he discarded analytical proofs, always preferring purely geometrical methods. Before he left the Ecole Polytechnique, that is before completing his twenty-first year, he had devised a demonstration of the double generation of the hyperboloid of one sheet of which the celebrated Monge had previously given an elegant analytical proof. This alone proved him to be endowed with no ordinary mathematical power. In 1814 he exchanged his books for the sword, and took part in the defense of the capital; on the conclusion of peace he returned to his studies, obtaining the second place at the final examination which shortly afterward followed. The first candidate on the list was Giorgini, a brilliant student, who had the frankness to admit that he owed his unlooked-for success, in great measure, to the assistance of his class-fellow and competitor.

The military career had but few attractions for Chasles, and he soon made up his mind to relinquish altogether the uncongenial profession of arms. He withdrew to Chartres, where he devoted himself with renewed ardor to his mathematical studies to such an extent as to draw from his friends exclamations of regret at the sad waste of so much talent. But time belied their vaticinations, and few years elapsed before Chasles was looked upon, in the scientific world, as among the most promising of the younger generation of mathematicians.

In 1829 the Brussels Academy offered a prize for the best philosophical discussion of the methods recently introduced into geometry and especially the method of reciprocal polars. This was an opportunity for Chasles, and he replied in a masterly way by his "Aperçu Historique sur l'Origine et les Développements des Méthodes en Géométrie." Such is the modest title he gave to a work which a competent judge calls the most learned and original contribution ever made to the history of science.

From time to time M. Chasles wrote interesting historical essays on various branches of the exact sciences. He studied with great care the works of the Arabians and Hindoos, and in 1843 published his "Histoire de l'Arithmétique," in which he maintained, contrary to the received opinion, that we owe our system of notation to the schools of Magna Græcia and not to the Arabians.

In 1852, appeared his great work, the "Traité de Géométrie Supérieure." It was specially written for those who followed his lectures at the Sorbonne, and was the first elaborate treatise on modern geometry. We should, however, add that Dr. Mulcahy, of Trinity College, Dublin, published, in the same year, his "Principles of Modern Geometry," a treatise which, though good in its time, has been superseded by the works of the Rev. Prof. Townsend. Quite recently M. Chasles rewrote his original work, and had the satisfaction of seeing the last sheets through the press a few months before his death. In 1865, he completed his second great work, viz., "Les Sections Coniques." All subsequent writers on this subject have largely drawn on this famous treatise. Indeed no book would now be considered complete without embodying the more important of Chasles's discoveries. The reader of Salmon's Conics—which is unquestionably the best English text-book we possess—will remember with what frequency the labors of the French geometer are referred to.

Though far advanced in years, M. Chasles continued still to be an indefatigable worker, as the *Comptes Rendus* bears abundant evidence. He would never miss the weekly meetings of the Academies nor fail to hold the evening receptions, at which he entertained, with equal grace and hospitality, the most distinguished scientific workers and the leaders of thought of the French capital. Simultaneously with the revision of his treatise on Modern Geometry, he proceeded with a "Histoire Générale de l'Ecole Polytechnique," but time was not given him to finish this work of love. It is, however, pleasing to know that this historical sketch of the great French school is well advanced.

M. Chasles had completed his eighty-seventh year when summoned away from the sphere of his extraordinary activity and well-deserved triumphs. A fellow-academician of his, M. Bertrand, has summed up his life-work in these words: "More than once M. Chasles, while adopting purely geometrical methods, has shown with rare success, the narrow and mysterious link that unites the various mathematical truths. We are indebted to him, in one of the highest and most difficult theorems of the integral calculus, for several elegant and much admired deductions; he contributed to mechanics a classical chapter on the displacement of solids; he discovered, in the theory of attraction, beautiful and general properties which have completely renewed the theory of statical electricity, while his papers on the attraction of ellipsoids, admired and praised by Poinsot, have excited a noble emulation among analysts and pure geometers, to the great advantage of science.

M. Chasles was appointed in 1841 to the professorship of geodesy and applied mechanics in the Ecole Polytechnique; in 1846 the chair of higher geometry at the Sorbonne was specially founded for him, and in 1851 he was elected member of the Institute of France. Our Royal Society, fully appreciating his numerous and profound discoveries, and nominally his theory of characteristics, awarded to him in 1865 its most coveted distinction, the Copley Medal.—*Engineering.*

NEW METHOD OF RAISING SUNKEN VESSELS.

By DR. W. RAYDT, Professor at the Lyceum, Hanover, Germany.

EXPERIENCE shows that the most important inventions are often not carried out practically for years, because the needed capital and enterprise are lacking. Such an invention, the utility and advantage of which are unquestionable, is the method by which heavy bodies under water—for instance, sunken vessels—may be lifted by means of carbonic acid gas made liquid by compression, of which we will give an account, and which has been patented in the countries mentioned below.

The mathematical correctness of the calculations in regard to this invention has been testified to by eminent German physicists and mathematicians. The well known Professor Weber, in Göttingen, more especially, has given testimony to this effect, and has expressed his unlimited confidence to the inventor, who is also in possession of a commendatory letter from Field Marshal Count Von Moltke.

A completely satisfactory demonstration of the practicability of this new method has been made before competent witnesses on August 28, 1879, in the outer reservoir of the Imperial Wharf at Kiel, the more important details of which are given in the following account, signed by responsible persons of high standing:

"KIEL, August 28, 1879.

"Under the above date a trial was made by Dr. Raydt at the Imperial Wharf, in presence of the undersigned, in order to test his new method 'of inflating balloons rapidly under water by means of carbonic acid gas rendered fluid, and thereby to lift objects immersed.'

"The balloon to which the reservoir containing the gas was attached was fastened to an anchor block of 15,000 kilogrammes weight, and immersed to the depth of 10 meters under water, when the valve of the reservoir was

opened, and eight minutes subsequently the wholly inflated balloon appeared on the surface of the water, bearing underneath the anchor block. The lifting has therefore been entirely successful.

"The Superintendent of Equipment of the Imperial Wharf at Kiel. (Signed) "KROKISIUS.

"The Superintendent of Harbor Buildings for the Imperial Marine. (Signed) "G. FRANZIUS."

The purpose of this demonstration was to prove how easily the Grosser Kurfürst, sunk in the Channel, could be raised at comparatively small cost. None of the witnesses doubted the feasibility of this method, but the German Government would not bear the expense of the trial; it would, however, gladly enter into favorable arrangements with a company formed for that purpose. The treasures lying at the bottom of the sea are immense, and a company formed for the purpose of raising them by a safe method would gain great riches.

The methods hitherto employed for that purpose are very imperfect. The best mode is to fasten airbags to the object to be raised.

The capacity of bearing of a hollow space under water is very great; it is well known that it is equal to the weight of the water displaced. The bearing capacity of a hollow space of 1 cubic meter amounts to 1,000 kilogrammes.

Accordingly a balloon, in form of a globe, of 3 meters radius would possess a bearing capacity of more than 113,000 kilogrammes; while one of 4 meters radius would be able to lift upwards of 268,000 kilogrammes.

The novelty of the new method consists in this: that the airbags are filled with great convenience, the work of pumping being done on shore, and the airbags filled with compressed gas in reserve, which can be used suddenly at a given moment to fill the balloon; unlike the old method, by which airbags are gradually filled on the surface of the water by long tubes with compression pumps.

The leading idea in this new procedure is the following. The gases (especially carbonic acid gas) become liquid by compression and then occupy a very small space, while as soon as the pressure ceases the liquids resume the gaseous form and fill the previous large space. Carbonic acid gas (which moreover is the cheapest gas) assumes the liquid form at the freezing point under a pressure of 36 atmospheres, and in this state occupies $\frac{1}{500}$ of its previous space. A small reservoir may therefore contain an immense amount of gas.

Under common atmospheric pressure, two liters of liquid carbonic acid gas fill in their gaseous state a space of 1,000 liters, or 1 cubic meter.

If a heavy burden lying under water is to be lifted, a sufficient number of airbags must be fastened to the object; each balloon is to be connected with a reservoir containing an adequate quantity of liquid carbonic acid gas, by means of which the airbag can be quickly and safely filled at a given moment.

The table below shows the capacity of bearing of globular balloons, and the amount of fluid carbonic acid gas necessary to inflate them in cases where the balloons are submerged ten meters under water.

Radius of balloon.	Capacity of bearing in distilled water (4° Celsius).	Weight of liquid carbonic acid gas necessary for inflation at 10 m. depth.
1 meter.	4,189 kilos.	13·4 kilos.
1·5 "	14,138 "	45·2 "
2 "	33,510 "	107·2 "
2·5 "	65,450 "	209·4 "
3 "	113,097 "	361·9 "
3·5 "	179,594 "	574·7 "
4 "	286,083 "	857·9 "

Suppose a sunken ship is to be raised, or one aground to be set afloat, a steamer carrying the needed material must go to the spot.

Situation, weight, cargo of the ship, have first to be ascertained; then divers have to find the most available places to fasten the airbags. They are then to be connected with their reservoirs, and filled so far with carbonic acid gas or atmospheric air that they are able to carry their own and the weight of their reservoirs, and to remain in upright position under water. Then they are lowered, and fastened in the most suitable manner on to the ship. Mr. Raydt has devised several ingenious methods by which the balloons may be thus fastened, even on iron ships. Frequently it will be possible to place balloons in the hollow spaces of ships, and to fill them from a reservoir placed on deck of the wreck, by means of gutta percha tubes. The experiments made by the inventor have proved that the liquid gas will pass through such tubes.

When all preparations are made, the most favorable time for lifting the vessel and setting it afloat is chosen. When this has arrived, all the valves of the reservoirs are opened simultaneously by divers or by means of ropes from above, the balloons are filled rapidly, and the lifting of the vessel takes place at once.

A few balloons are already sufficient to lift common vessels, even if they are of iron and freighted; but even monsters as the modern men-of-war may be lifted in the same manner. The Grosser Kurfürst, for instance, which under water has a weight of 5,000,000 kilogrammes, might be raised by 19 balloons of 4 meters radius, the length of the vessel (94 meters) being sufficient for fastening the same.

While it is necessary, according to other methods for lifting ships, to keep up a continuous connection with the surface of the water for weeks, even months, in the method just described this is not necessary. On favorable days the needful work on the sunken ship may be done; it may be interrupted and resumed when desirable; and finally the apparatus for lifting may be left fastened until it is deemed advisable to use it. The experience in lifting vessels according to the old methods show many cases where storms have destroyed the preparations and work of many weeks. By the application of the new method, however, the disturbed condition of a stormy sea has relatively little influence on the success of the enterprise, as the means for lifting, once fastened, may be used at any convenient time, and will then do their duty promptly and safely. If the steamer furnished with the necessary material which is to assist in the lifting of a vessel is soon on hand, it can be set afloat in a very short time; under favorable circumstances a few days will suffice. Especially will this be the case when a vessel has been wrecked. Only a few—say four—airbags, suitably fastened, will suffice to lift the vessel sufficiently for setting it afloat.

What has hitherto been said in favor of the new method is no mere theory; its practicability has been tested, and all difficulties have been practically overcome.

The liquid carbonic acid gas had only been heretofore obtained in small quantities by means of a compression pump worked by hand; it was therefore necessary to show that the fluid gas could be obtained in large quantities in an easy, cheap, and safe manner. This was done by a steam compression pump made in the machine factory of Mr. Egestorff, in Linden, near Hanover. The difficulties which arise in the manufacture of small quantities of carbonic acid gas do not show themselves in the production of larger quantities. The inventor obtained in one day, with his small pump containing a cylindrical space of one liter, without any difficulty, more than 40 liters of fluid carbonic acid gas, a quantity which probably had never been obtained in all Germany. The same factory has agreed to furnish a compression pump of 40 times greater power than the one above mentioned, so that in one day more than 1,600 liters of fluid carbonic acid gas could be manufactured.

The expense of the gas depends largely upon the quantity which is produced; it will probably not exceed 5 or 10 cents per liter of the liquid gas, and will be still less when manufactured on a large scale.

The trials have also shown that the gas streams out of the reservoirs and fills the balloons very rapidly and without danger.

The balloon of 3 meters diameter and 14,138 liters capacity that had been used in the trials under water as well as in the air, was inflated in five to eight minutes.

It was feared that the filling of the balloon would be interrupted by the cold that would be induced by the outstreaming of the gas, but the trials have shown that this has not been the case. The explanation of this phenomenon is in the first place that a small fraction of the outstreaming carbonic acid gas, at most 3 per cent., was transformed so as to resemble snowflakes, and thus gave out sufficient heat to change the remainder of the fluid into gas. In the second place the particles of water next to the balloon, which became colder by the instreaming of the gas, grew heavier, and therefore sank, thereby making room for warmer particles of water, which in turn, when cooled, sank again, until by this circulation of the water the temperature of the balloon was made equal to that of its surroundings. In fact the balloon used at the trial in the Bay of Kiel, when withdrawn immediately after its inflation, did not show the least particle of an ice like formation.

As it is known that carbonic acid gas becomes fluid at the freezing point under a pressure of 36 atmospheres, it is evident that the reservoirs must be sufficiently strong. Every danger, however, that might arise may be prevented by previous trials of the powers of resistance of the reservoirs. The chances of explosion are not as great as in boilers of steam engines, for these wear out from the rust produced by the water, and by the steam and air with which they are filled. Besides they are exposed to fire, by which they suffer; and a sudden development of large quantities of steam under high pressure makes them liable to explode. All these dangers are avoided in the case of the reservoirs filled with fluid gas; the metals of which they are constructed are not affected by contact with the gas, nor can a higher pressure suddenly be developed, so that with the necessary caution no danger is incurred. Should it be desirable to diminish the pressure, it may be done by adding another gas to the carbonic acid—say sulphurous acid, which at the freezing point under pressure of 1½ atmospheres becomes fluid. The balloons may be constructed out of canvas coated with India-rubber, or made otherwise impervious; they must be covered by a netting of strong cords, which join underneath; and may be fastened by chains to the hooks destined for the lifting process. The pressure from the inside of the balloon is about equal to that from the outside, as the pressure of the gas is equal to that of the water from without. Still when the balloon rises in the water, and the pressure of the water diminishes, it is necessary, in order to avoid all danger of an explosion, to let the superfluous gas out. For this purpose the bottom piece of the balloon is furnished with self acting safety valves, which open as soon as the outward pressure diminishes, and let the superfluous gas out. In proportion to the advantage the expense of this new method is very small, considering that the larger outlay for the airbags, net of cords, and reservoirs, is only once necessary, and only the filling with the very cheap carbonic acid gas has to be renewed.

To give a proximate estimate, it may be mentioned that the Hamburg steamer Pomerania (sunk in the Channel), which was insured, *without* cargo, for the sum of $400,000, would be sold at present, although her position is a very favorable one, for a few thousand dollars, while the expense for the whole of the material necessary for lifting her would be about $15,000. For lifting the Grosser Kurfürst the German Government has agreed to pay $250,000, while the cost according to our method would be, on an average, $50,000. The lifting of the Vanguard would be even more profitable, for the English Government had once offered to a contractor the sum of $750,000 for it.

PRELIMINARY REPORT UPON THE IMPROVEMENT OF THE NAVIGATION OF THE MISSOURI RIVER.

By MAJOR CHAS. R. SUTER, United States Engineer.

THE importance of the subject can hardly be overestimated, as this river is the longest of any in the United States, and is, with the exception of the Ohio, the largest tributary of the Mississippi. Its channel length from its source in the Rocky Mountains to its junction with the Mississippi near St. Louis, is probably something over 3,000 miles, and it brings forward the drainage of an area of 572,672 square miles. It is navigable for nearly its whole length, for the portion above the Great Falls, near Fort Benton, is already provided with several small steamers. Its tributaries, though often of great length, are not of great size, and are rarely navigable in their present condition.

The country through which the Missouri flows is mostly one of small rainfall, so that its really large discharge is due to the great area of its drainage basin and the mountain snows and ice near its head waters. Its most salient and striking features are the remarkable impetuosity of its current, and its slope, which is considerable for so large a stream. The rapidity of the current and the general instability of the banks and bed give rise to the excessive turbidity of its waters, which have earned for it the title of the "Big Muddy." It is, in fact, the greatest silt carrier in the country, and the enormous mass of sediment which it brings forward forms the great bulk of that received by the Mississippi from its tributaries. Its influence upon the main river is most marked; indeed it is its prototype in its main physical features, and from the navigation point of view, at least, it may be said to have a marked controlling effect upon the main trunk stream. The subject of its improvement, therefore, is not only of local interest, but is of the greatest general importance, now that the improvement of the Mississippi is receiving serious consideration.

The portion of the river to which this report is confined is 781 miles in length, and extends from Sioux City to the mouth. The general direction of the valley from Sioux City to Kansas City, 406 miles, is slightly east of south; for the remaining 375 miles it is nearly east and west.

For the period covered by possible navigation—that is, the period when the river is unobstructed by ice—the range of water surface varies from sixteen to twenty feet at different localities and in different years. During the winter the river may fall three or four feet lower, and unusual floods may increase the height by an equal amount or even more, as in the great flood of 1844. This latter flood, however, was entirely abnormal, and due to causes of which we have at present no definite knowledge.

The amount of water discharged is, however, subject to a much greater variation than this range of surface elevation would imply. Our gauging observations at Saint Charles, near the mouth of the river, showed a variation in 1879 from 26,446 to 298,537 cubic feet per second for a range of seventeen and one-third feet on the gauge, or a low-water volume about one-eleventh that of high water. From these observations it was further inferred that the ordinary range of the gauge would give volumes of about 15,000 and 430,000 cubic feet per second for high and low water respectively. This would make the low-water volume about one twenty-eighth that of the high. At Sioux City, 781 miles above, the variation in discharge was about the same, while the total discharge in passing over this distance was increased about 100,000 cubic feet per second in flood, and 8,000 cubic feet at low water.

The regular floods are two in number, and usually occur in April and in June. The first is extremely violent and of short duration, rarely lasting over a week or ten days; it seems to come largely from the upper river. The June rise, although generally higher, is of longer duration, being influenced by local rains and the general saturation of the soil. It is followed by a steady fall, which continues with considerable regularity till the freezing weather closes the small affluents as well as the upper river; then a sudden fall of three or four feet takes place, and the river reaches its winter level. There are occasional small rises of short duration besides those mentioned; one, especially, usually occurs late in the fall, but the two first mentioned are from all points of view the most important. The rate of travel of the crest of these floods is, on an average, about six miles per hour. The April rise is generally the most destructive, for it shows, for a time at least, a tendency to follow the channels developed during the low water season preceding, and, as a consequence, the banks are attacked with extreme violence. When the June rise comes, the bed is in a measure shaped for its reception by the preceding flood, and the water passes off with somewhat less destructive results. Both, however, have sufficient power to produce tremendous effects and bring about the most astonishing changes.

The main valley of the river consists of a great rock trough, from one and a half to seventeen miles in width, cut down from the general level of the country to a depth considerably below the present level of the valley. The rocky banks form bluffs along the stream, and the bed is also of rock. This great trough seems to have been filled at one time with the glacial drift deposits, which also cover the adjacent country, and subsequently in part cleared out by the great river that probably occupied it in early postglacial times. The drift deposits seem everywhere pretty well sorted out, bowlders are generally found next the rock, and deposits of varying degrees of coarseness above. The main feature is the great preponderance of extremely fine sand, which, with the addition of a very small amount of alumina, forms an extremely tenacious clay, locally known as "gumbo," and which is met with everywhere, and is formed in the bed of the stream wherever the current is unusually slackened. Large beds or pockets of very coarse gravel or pebbles are also met with in borings at different depths below the surface. They are usually water worn fragments of quartz, mostly red and yellow jasper. The general absence of the large, high, and well-defined terraces, which are usually found in valleys of this description, and the general prevalence in the surface soil of the very fine sand before alluded to, leads to the inference that the river, within comparatively recent times, has scoured over the greater part of the area embraced between the limiting bluffs, at least in the narrower portions of the valley. The valley below Saint Joseph averages about two and a half miles in width; above that point it is wider, reaching seventeen miles in the neighborhood of Sioux City.

The general depth of the rock bed below the surface of the valley varies from seventy to over one hundred feet wherever borings have been made. The piers of the numerous bridges erected are founded on rock in most cases, and the borings which have been made at these and other proposed bridge-sites, together with work done under my own direction, enable me to assert with considerable confidence that no rock in place will be met with at a higher level. At the few places where it is found in the bed of the present stream spurs or ledges projecting from the main bluffs are the cause, while the general depth of the rock valley beyond these ledges is unchanged. Moreover, if at any place rock did occur at a higher elevation within the bed of the stream, it would be indicated by a local increase of slope, but such is nowhere the case, except at the points alluded to. As I am of the opinion that at these few points the obstructions can readily be flanked, I think it perfectly safe to count on any amount of depth of channel deemed necessary within the limits stated. At some points on the river layers of bowlders of considerable size form the bed of the stream in flood, and have been mistaken for rock in place. At Saint Charles the piers of the bridge pass through a layer of this description, but the bed rock was found below the bowlders, and at the usual level.

As may readily be inferred from a comparison of the volume of discharge with the variation in level of the water surface, the velocity of the current is very great. At low water the average is from two to three miles per hour, while in floods it amounts to ten miles per hour or more. Owing to this cause, and also to the large amount of very light material in the bed and banks, the amount of bank erosion and scour and fill of the bed is very great and very rapid. Bank erosion to the extent of two thousand feet per annum, over long distances, has been noted, and to a greater or less extent it is constantly going on, even during low stages. The enormous amount of material thus precipitated into the river, together with that scoured from the bed, causes the formation of innumerable bars, which, even at high water, obstruct navigation. These bars are constantly in motion, their position and shape changing from day to day. The channels through them are also changing both in depth and location, rendering navigation correspondingly uncertain. Owing to the incessant bank erosion the river is steadily increasing the width between high banks, as the bars which are formed opposite caving shores take time to build up to

the general level, and are meanwhile liable to be themselves attacked and swept away. The erosion, which usually occurs on the upper sides of points, causes these points to move bodily down stream. Where the erosion is more rapid than the bar-growth below the point disappears, and the river's course is detrimentally straightened. Where a point or projecting neck is attacked on both sides, a cut-off is soon formed, which also acts detrimentally by increasing the local slopes and inaugurating other destructive changes. The caving of the banks precipitates into the river countless trees, which form the snags that constitute, in the strong current, most serious dangers to navigation, and also assist in impeding the free flow of the stream. The slopes vary from point to point, being, as usual, greatest on the crossings of the bars, and less in the pools above them. The general slope of the river, however, as determined by simultaneous gauge readings, is remarkably uniform. It averages 0·88′ to the mile both at high and low water.

Owing to the great movement of sand, when the current is strong, the bars are rapidly built up as the river rises, and although elsewhere the river follows the general law of scouring its bed at high water and filling it at low, yet at these places of local engorgement the depth over the bars, as also in the channels leading through them, is much less than the low water depth plus the rise of the water surface. The actual navigable depth of the river varies from about three feet at low water to nine feet at high water, though, of course, at the latter stage the channels are wider and the number of very shoal bars is reduced.

The amount of sediment carried by the river is very great, and it is only when ice begins to form that the water becomes comparatively clear; at all other stages the water is muddy, the amount of sediment carried increasing with the volume of discharge. From observations carefully made at Saint Charles the sediment carried in suspension past that station for the year 1879 is shown to have amounted to 5,508,229,008 cubic feet, the water discharge for the same period being 2,335,148,946,400 cubic feet; the proportion by volume is 1 to 424, and by weight 1 to 265. For the single day, July 4, 1879, the amount of sediment thus transported would have covered a square mile to a depth of 4·041 feet, and during the entire year an amount of sediment passed Saint Charles sufficient to have covered a square mile to a depth of 197·58 feet. The samples of water that were analyzed were taken at the surface, the mid-depth, and at one foot from the bottom, and the arithmetical mean was taken for the mean result. The true amount would, therefore, of course be greater. Moreover the last foot of depth was not considered, but the increase in amount of sediment from surface to bottom was such as to lead to the inference that the amount moving in this lowest stratum might be fully equal to the amount actually collected. The observations also took no note of the material in motion on the bottom, known to be great in amount but never yet successfully measured. For these reasons it seems probable that the amounts above given would have to be at least doubled to get a just idea of the amount of solid matter brought into the Mississippi by the Missouri. On this supposition the total amount per annum would be 11,000,000,000 cubic feet, enough to cover a square mile to a depth of 400 feet.

An examination of the sediment samples collected shows that only the finer materials are carried in suspension within the limits covered by the observations; the coarser particles of sand are either rolled along the bottom or carried intermittently in close proximity to it. As might be anticipated, the water is so heavily charged with sediment that decrease in velocity is immediately followed by a considerable deposit, but the converse of scour following an increase of velocity, although apparent, is not so well marked nor so extensive. This is explained by the fact that the largest portion of the suspended sediment is undoubtedly due to the caving of the banks, in which process a much larger amount of material is thrown into the stream than is due to actual erosion. By this latter action the toe of the bank is undermined, and the upper portion, being unsupported, falls in, when the lighter materials of which it is composed are carried off by the water in a state of suspension, the heavier materials remaining on the bottom. The increase of velocity due to concentration, however brought about, sets up a very heavy scour on the bottom, the bed rapidly deepens, and the excavated material is carried away, the greater portion being probably dropped as soon as the local concentration of volume is at an end.

The regular formation and movement of sand waves is not conspicuous except at low stages; during floods the velocity of the current is so great and the bed so yielding that the materials composing it seem to be moved bodily in mass as if the bed were in a semi-fluid condition.

The difficulties of navigation are mainly due to the small depth on the bars, a description of which is essential to a proper understanding of the subject.

Wherever certain limits of width are exceeded the river very generally shows two narrow pools or channels of deep water, one adjacent to each bank. Between these lies a bar, the depth of water on which is much less than it is in either pool. The pools are narrow and deep, closed at each end, and so located that the head of any one lies opposite a point intermediate between the head and foot of the pool adjacent to the opposite shore. It is generally impossible to pass from one pool to the next succeeding one on the same side of the river, so that in practical navigation boats are obliged to cross the intermediate bar to pass from the pool on one side to the one opposite, then back to the next one, and so on.* The bars between the pools are often very extensive. They lie diagonally across the stream, alternating from bank to bank, and are often several miles in length. They are intersected by numerous channels of comparatively small depth. At low water large portions of these bars are laid bare, and under favorable circumstances a growth of willows will start on them, and they then become the nuclei of islands. After the willows get a good foothold the sediment arrested in floods gradually builds up the surface till it is too high for the growth of willows; cottonwoods then succeed, and finally other trees gain a footing, and the island is raised to the general level of the bottoms. In spite of this transformation the connection of the islands with the bar systems remains sufficiently obvious when long reaches of the river are considered.

The general dimensions of the bars depend mainly upon the width of the river. The exterior boundaries follow closely the outlines of the main shores, being separated from them by the water in the pools. In the space between the foot of one pool and the head of the next adjacent one, the bar joins the shore line, and its general direction then changing, it trends toward the opposite shore, which it reaches in the space between two adjacent pools on that side; then the general direction of the river is a curved line, the bars follow the curves closely, the deep pools lying next the concave shores. The general depth on the bars varies also with the width. Where this latter is but little in excess of that which does not allow a bar to form, the middle bar may be deeply submerged, and only indicated on a cross-section of the stream by a slight rise of the bottom near the middle width. Again, where the width is great, some portions, viz., islands, remain dry even at high stages; while the general position of the bars remains constant, their shape, the depth over them, and the position and depth of the channels through them, are constantly varying. The pools also are, to a considerable extent, influenced by these changes, portions being filled up or excavated from year to year, as the distribution of the flow of water over the bar varies. The side of the bar next the down-stream pool is usually quite steep, the depth on the bar crest is less than at other points, and the slope which connects it with the up-stream pool is very gradual. These bars, extending, as they do, entirely across the stream, act like low or partly submerged dams, and the ponding up of the water due to this cause gives rise to the pools in which the slope is much below the average, while on the crossing from one pool to another it is much above the average. Even at high stages this difference of slope is very conspicuous. In passing from one pool to another the water begins to pour over the bar at the head of the down-stream pool. After reaching the pool the water flows along the lower edge of the bar, receiving as it goes additional supplies from the sheet of water flowing over the bar crest. The volume of water in the lower pool, therefore, increases from its head to a point about opposite the head of the next pool of the series. When this point is reached the second pool begins to discharge into the third precisely as the first had discharged into the second, and its volume of water diminishes throughout the remainder of its length. Each pool, therefore, shoals toward its head and foot, and its width decreases also, though in a smaller proportion. The result of this double flow along the axis of the pool and across the crest of the bar, is to force the body of water in the pool against the bank, while eddies are generated, often of great size. Under these circumstances there is always a tendency to erode the banks, and in direct proportion to the amount of water coming over the crest of the bar. Where a channel is cut through the crest this action is very powerful, and erosion is generally initiated at such points. After an indentation is once made in the outline of the bank the eddy generated thereby extends the cutting down-stream for long distances, and where the shore line is curved the width of the swath thus cut out increases as it progresses down stream. As the bank recedes the crest of the bar advances correspondingly, its lower face being no longer swept clean by the current in the pool, till the original cross-section of the latter is re-established and the advance of the bar is stopped. In my opinion the caving of banks is almost, if not entirely, due to this action. Where the current flows parallel to the shore without cross-currents or eddies there seems to be but little, if any, erosion.

At many points along the river are found reaches of moderate length where the width is too small to allow the formation of a middle bar. At these places, often very narrow, the whole volume of water, even in floods, flows in a concentrated mass, the direction of the current being parallel to the banks. From the date of the ear. st land surveys (1817) these places seem to have remained almost unchanged, there having been very little erosion. At these places, as the river rises, the bed regularly deepens, and it fills up again as the river falls, leaving the relative section unchanged from year to year, while the depth, even at low water, is much greater than the average. The slope is usually less than the mean slope of the river. The pools also are of this same general type, but more exaggerated and modified by the peculiar manner of their formation. If the bar crest above them were dry, and all the water entered them through one channel, they would be entirely similar.

During flood stages the general movement of sand is, in a measure, arrested on the shoals, and, as a consequence, the low water channels leading through them are silted up, while new ones are developed which accommodate the high water flow. As the river falls these latter channels are silted up, and the water ponds up behind the bar until sufficient head is attained to form a breach through the crest at one or several points. These breaches are the low water channels, and through them boats have to pass on their way from one pool to another. The depth in these channels depends mainly on the number; where there are many, and there is also a considerable flow over the crest of the bar, the depth is smallest and navigation the most impeded; where the flow is more concentrated, the depth is proportionately increased.

During the course of the low water season the main channel keeps shifting from one subsidiary channel to another; these changes of location are often very great, and the uncertainty thereon attendant forms one of the greatest drawbacks to navigation. The high water channels, before alluded to, are, in the Missouri, of the same general character as those of low water, but they rarely coincide with them. They are less tortuous as a rule, but not of much greater depth, and they are liable to the same rapid changes of location.

The main points, to which attention should be directed, are the constantly varying slopes, cross sectional areas, and velocities. At the narrow reaches and in the pools we have a small slope and small cross-sectional area, especially characterized by great depth, small width, and high velocity; while on the shoals we have an excessive slope, a very large area of cross-section, with excessive width, very small depth, and low velocity. The amount of water passing is the same in both cases, but the ratio of frictional surface to area of water-way is small in one case and large in the other. The increase slope observable in the last case is its direct and necessary consequence, as the additional head thus created alone enables the water, when flowing through the larger cross-section, to overcome the added resistance due to the increase of frictional surface. It is evident from this fact that the contracted section is more favorable for the discharge of a given volume of water than the other, as the mean velocity is greater, while the slope is much less.

Now, it must certainly be admitted that, at any point and at any time, a river adjusts itself to the various conditions imposed upon it by the bed through which it flows. As the volume of discharge increases, the surface of the water rises, the river spreads out laterally, and thus obtains greater area of cross-section, while the velocity of the current increases. But on rivers flowing through alluvial deposits a further change takes place, for, the bed being of a yielding character, the increased velocity of the current is sufficient to set up scour, which is greater or less according to the increase of velocity and the relative stability of the bed. At the concentrated sections, where a great increase of velocity takes place, this scour is large; whereas at the wide, shallow sections, where the increase of velocity is small, the bed not only does not scour, but actually fills up, as the materials scoured out of the deep pools are arrested there by the decreased velocity of the current. When the river falls, the velocity of the current over the shoals is locally increased, while that in the deep pools is slackened. Local scour then sets up on the bars, and the materials thus removed are dropped in the pools, where the current is no longer strong enough to move them, and as a consequence the bed of the pool rises. It is the same with the materials precipitated into the river by the caving of banks; the lighter materials are swept off in suspension, while the heavier sand is carried through the pools by the strong current there prevailing, and dropped on the shoals below, where the velocity of the current is less.

Such, in very general terms, are the nature of the changes that take place, and it being obvious that the difficulties of navigation arise from lack of sufficient scouring power at special localities, all systems of channel improvement seek to remedy this difficulty by concentrating the flow of the water at such localities. The method usually followed seeks to concentrate the whole low water discharge and a portion of that pertaining to higher stages into one channel of such dimensions as will best subserve the special object aimed at. This system generally commends itself on grounds of economy, the extent of the works required being, as a rule, small. It is, however, open to many objections. In the first place, its scope is limited, only a moderate improvement being possible. In the second place, it is uncertain, as the amount of the deposit of floods varies from year to year, and may at times be in excess of the capacity of the works of improvement to remove rapidly after they begin to act. In the third place, it is not necessarily permanent, as the high river over which it has no control may, by abrasion of banks and other means, effect such changes as to render the works useless, or even cause them to become actual obstructions. All these difficulties are enhanced when the river is large and its regimen very unstable, and, on the Missouri, this cause alone would, in my opinion, render such a system entirely impracticable. The only system which promises results of permanent value here is one which will control the river at high as well as at low stages. The points which such a system should seek to obtain, at least approximately, are, at any stage, equality of cross-section both in width and depth, uniformity of slope and in consequence uniformity of velocity, while the channel at all stages shall be permanent in location. The width should be such that at high stages the bed will be scoured to the greatest attainable depth, while at low water the greatest depth compatible with navigable width will be retained. The slope should be as small as it is possible to obtain within the limits of the present banks. The volume of discharge, the attainable slope, and the depth to unyielding strata, in this case bed rock, will alone limit the scope of such an improvement. It would not, of course, be possible to bring the whole river to the dimensions of the pools, as the small slopes which exist there could not be obtained, but a mean result corresponding nearly to the average slope of the river is possible. After a careful study of all the data collected, I am of the opinion that for the portion of the Missouri River under consideration, about eight hundred miles in length, and extending from the mouth to Sioux City, Iowa, a uniform navigable depth of twelve feet at lowest stages can be guaranteed. This depth would allow boats to load to eight or nine feet, and run with perfect freedom, while at higher stages the depth would, of course, be much greater. To effect this improvement the high water width of the river must be decreased and be brought within certain limits which increase with the increased volume as we proceed down stream, while the general direction given the rectified channel must be such as will insure the smallest slope attainable consistent with other conditions. Approximately these high-water widths are as follows:

	Feet.
From Sioux City to mouth of Platte	820
From mouth of Platte to mouth of Kaw	960
From mouth of Kaw to mouth of Gasconade	1,160
From mouth of Gasconade to the Mississippi	1,240

At low water these widths become, respectively, 650 feet, 820 feet, 1,020 feet, and 1,100 feet, the low water and high water lines being connected by slopes flat enough to be permanent. The increase of width at high water is nearly such as, with the scour on the bottom, will insure the requisite area for the flood discharge. The dimensions of the high water section are, therefore, regulated by those of the low water section, which is designed to insure a definite depth of twelve feet at lowest stages. The scour which it is expected to induce by this contraction is under, rather than above, what commonly occurs at all the deep sections along the river, and is thought to be readily attainable. When a channel of the dimensions indicated has once been cut through the shoals, any impediment to navigation due to these latter will, of course, disappear, and they cannot reform because, the velocity being uniform, there can be no tendency to deposit at any one place more than at another. As the river falls from high to low water the bed will be uniformly silted up from one end of the river to the other, but not to such an extent as to diminish the expected low water depth.

The range of elevation of water surface from high to low stages will, of course, be somewhat increased, but the actual elevation of floods will probably be lower, as there will be no local engorgements of sand as at the present shoals to raise the surface of the water and diminish the freedom of flow. The whole of the river bottom will, therefore, be benefited in this way, in addition to the security conferred by the works against destructive bank erosion.

To accomplish these results it is proposed to employ the methods already successfully applied for some years past at various points along the river, and which have been described at length in my annual reports. By the use of suitable devices the velocity of the current is checked where desired, so as to induce a deposit of the sediment which it carries. By taking advantage of the season of floods, when the amount of material moving is large, deposits of very great extent can be readily induced.

The object is to so locate these deposits that they shall occupy those portions of the river bed that it is designed to abandon, leaving unobstructed those portions to which it is desirable that the channel shall be directed. The river is thus expected to build up the new banks and excavate the new channel. By following up this action it is anticipated that after one or two seasons the rectification will be completed and the new banks will be raised sufficiently high to support a growth of vegetation. They, and all other banks exposed to erosion, will then be protected by light mattress revetments. The work so far done under this permeable system of improvement, although largely experimental, has given very encouraging results, and the cost of the silt-catching devices, revetments, etc., has been brought to very low figures, so that in the case of a river which, like the Missouri, is very heavily charged with sediment, works may safely be projected to accomplish results of a scope and magnitude utterly unattainable by any other methods.

Work already done furnishes me the means of approximately estimating the cost of this improvement, which, if carried out on a large scale, and with liberal appropriations, will probably not exceed $10,000 per mile. This would put the cost for the whole eight hundred miles under consideration at $8,000,000, and from Kansas City to the mouth of the river at $3,750,000. If this work is undertaken it will, in my opinion, be absolutely necessary to confine the work at any time to such a length of river as will allow of the rectification being entirely completed with the sum appropriated. In other words, the money should be allotted to the improvement of a certain reach of the river, and the engineer in charge should be left entirely untrammeled to decide how and where within that reach the money should be expended. In order to economize in the outlay for plant, these reaches should be in lengths of not less than fifty nor more than one hundred miles, and the work should be continuous—that is to say, as soon as one reach is finished the next in order should be taken up. For many reasons it would be advisable to begin at the mouth of the river and work up stream, making the improvement continuous and complete as it progresses. It must be distinctly understood that the estimates submitted are based upon the supposition that work will be carried on in the manner indicated; if the money is to be frittered away at isolated points, and the improvement carried on in a disjointed and arbitrary manner, no estimate of the ultimate cost is possible, but it would probably be three or four times greater than the figures given here. In work of this kind it is essential, both for the sake of economy and to insure ultimate success, that the money shall be available when work can be done to best advantage, and in such amounts that each separate piece of work may be pushed at once to completion. Anything left unfinished is pretty certain to be destroyed, and the ultimate cost will thus be enhanced, not to mention the trouble and expense attendant on the frequent revision of plans thus rendered necessary.

The benefits attendant on such an improvement can hardly be over-estimated. With a guarantee that at lowest navigable stages a safe and permanent channel, having nowhere a less depth than twelve feet, will be available, boats and barges as large as any now used on the Lower Mississippi could be built and safely navigated. They could also be provided with heavy power and staunch hulls such as would be needed to cope with the strong current of the Missouri River. Snags, which now are great and ever present obstructions, would be to a great extent swept away by the deep scour of floods, and the supply of new ones would be materially reduced by the general prevention of bank erosion. The amount of sediment carried into the Mississippi would be proportionately reduced by the same work, and very substantial benefit be thus indirectly received by that river. The whole valley of the Missouri is extremely fertile, and if reclaimed, as it would be by this improvement, would soon all be under cultivation, and the amount of grain which would seek the river transportation would be enormous. The estimate for the whole work thus sketched out is $8,000,0 0, which could, with due regard to economy, be expended at the rate of $1,000,000 per annum. At this rate the whole improvement would require eight years for completion, or from Kansas City to the mouth four years, with proportionate increase of time if the annual appropriations should be smaller than here indicated.

THE INSTITUTION OF NAVAL ARCHITECTS.

The annual meeting of the Institution of Naval Architects for 1881 began on the 6th of April. The President, the Earl of Ravensworth, filled the chair. He said that at no time before did so many questions of importance present themselves for consideration in connection with the institution, and he now proceded to dwell at some length on the present commercial position of Great Britain in general, and of her shipping interests in particular. He found the Clyde held her honored position at the head of the list, having built last year one-half more tonnage than she did in 1879, and 1879 was a very fairly active shipbuilding year all over the kingdom. The Wear built one-third more than in 1879. The Tees more than 50 per cent. increase over 1879; the Tyne only built one-tenth more, and she actually built twenty-one vessels fewer, but she built upwards of 10,000 tons more shipping than in 1879. Now, that was important, because it showed that the efforts of our ship builders were directed to larger and more powerful, and consequently swifter vessels. The figures were as follows: The Clyde built, in 1879, 191 vessels, with 168,460 tons; in 1880 she built 209 vessels and 236,579 tons. The Tyne built, in 1879, 180 vessels and 139,843 tons; in 1880 she built 109 vessels only, but with 149,082 tons. The Wear built sixty-five vessels in 1879, and 92,176 tons; and in 1880 seventy seven vessels, with 116 227 tons. The Tees built twenty-five vessels, with a tonnage of 31,756; and in 1880, thirty-eight vessels, with 48,506 tons; and the value of the vessels in the north-eastern ports, built last year, amounted to seven millions of money. In February last there were building in the various ship-building establishments in this country no less than 650,000 tons of shipping under Lloyd's rules, and in addition to that there were 150,000 tons more not under Lloyd's qualification, making a total of not less than 800,000 tons of shipping in course of construction in February last. Our steam fleet had increased since 1850 from 1,350 vessels to 6,690 vessels, representing 2,730,000 tons of shipping, or one million more tons than of all other steamships of the world put together. He was therefore justified in saying that we held a very fair position in the carrying trade. He knew that some high authorities thought that steel was the material for the future, both for our merchant and for our war vessels; but, at the same time, they must remember that price has a great deal to do with material, and the present price of steel would probably for some time to come be a serious impediment to its employment for the ordinary ship and rougher description of merchant vessels. But there were eminent authorities, and he was rather disposed to be with them, who considered that the days of iron for ship-building purposes were numbered. He wished to quote a fact from the chairman of the Cunard Company to show the advance in Cunard ocean steamers. He said that when the Britannia made her first voyage, forty years ago, she measured 1,139 tons, cargo capacity 225 tons, and she steamed 8¼ knots. Referring to the French bounty system he said that the French bounty upon the first cost of a vessel had been variously estimated to be very nearly one-fifth of the cost. Supposing a vessel to cost £50,000, the bounty would amount to something very near £12,000. But there was another branch of it. There was a bounty upon the navigation of the vessel amounting to 1½f. per registered ton per 100 miles run on any direct line. Now that had been calculated to amount in one year to 17½ per cent. upon the first cost of the vessel, and he would put the navigation bounty at 12½ per cent. more upon the navigation, which amounted to no less a sum than 30 per cent. of the capital invested in that ship in one year. The effect of that appeared to him to be to put absolutely at least half that amount into the pocket of the shipowner in the shape of profit. We must look to greater care in the conduct of experiments upon designs in our shipbuilding establishments in order to bring ingenuity and theory to the test of practice

These were the objects and purposes of this institution, and it is in the fulfillment of this great purpose that they would gain for themselves that to which he thought they were fairly entitled—the title, namely, of one of the most useful and practical institutions in the country.

The first paper read was by Mr. J. D'A. Samuda,

ON THE ALMIRANTE BROWN ARGENTINE, CASED CORVETTE, AND THE EFFECT OF STEEL HULLS AND STEEL-FACED ARMOR ON FUTURE WARSHIPS.

The author said that the Almirante Brown was, he believed, the first vessel afloat which had been constructed entirely of steel and coated with steel-faced armor, and he believed that a reference to her guns carried, the armor-resisting power obtained, and the great capability of steaming without recoaling, would show advantages beyond those possessed by any previous vessel of similar tonnage and power, results mainly due to the material employed in the construction of hull and armor. This is a vessel of moderate size, combining all the latest improvements in construction, armor, and armament. The hull is built entirely of Siemens steel; the armor is "compound" or steel-faced, consisting of an armor belt extending 120 ft. in length, and protecting the engines, boilers, and magazines with cross-armored bulkheads at ends of belt reaching from 4 ft. below the water-line to the main deck. Above the main deck amidships is an armor-plated battery with double embrasures at the fore end, and containing in all six guns. The armor-plates are worked on a teak backing, and are screwed to the skin with bolts and nuts from the inside, so arranged as not to wound the steel face of the armor. Horizontal armor of steel plates is worked from the battery to the ends of the vessel, forming a shell-proof and water-tight deck 4 ft. below the water, protecting the steering apparatus, etc. The bottom is covered with teak planking 3 in. thick, and zinc sheathing from keel to 3 ft. above the water, as a protection against fouling. This vessel is fitted with a double bottom, and divided by transverse bulkheads and steel decks into forty-eight water-tight compartments. The plating of the hull varies from ⅝ in. to $\frac{7}{16}$ in. except behind the armor, where it is 1 in. thick. She has two pole masts, and an area of sail of 10,000 square feet. The armament consists of six Armstrong's improved type 8-in. 11½-ton long breech-loading guns fitted in battery, and so arranged as to give an all-round fire; one similar gun on upper deck forward and one aft; also six 4½ in. broadside guns on upper deck. Her machinery consists of two sets of inverted compound surface condensing engines of the collective indicated power of 4,500 horses—each set working its own screw, and being fitted in its own separate engine-room. The boilers are eight in number, cylindrical, the boiler room being divided into four separate water-tight compartments. The steel-faced armor used, 9 in. thick, has been found in practice to be equal in shot resistance to iron armor of 12 in. thick, and to resist a shot from a 12-ton muzzle-loading gun at 10 yards; while the guns used in this vessel, though weighing each only 11½ tons, are able to penetrate 13·3 in. of ordinary armor at 70 yards, and this is equal to the penetrating power of the surface muzzle-loaders of 18 tons in weight. Five of the guns can be brought to act almost in a direct line ahead, while an all-round fire is obtainable in which nearly every gun can participate. The speed is expected to reach 13¾ knots, and the coal carried is sufficient to enable the vessel to steam at a low rate of speed—say 8 knots—6,000 miles, or at a speed of 10 knots to cover 4,300 miles of distance. The effect of substituting steel for iron in the hull, and steel-faced armor for iron armor, has been to obtain the same strength and resistance to shot that could only be obtained in an iron vessel of similar size and strength with 510 tons additional material, and when increased in dimensions to meet this—as given below—a further 350 tons would be needed for the extra weight to the enlarged hull. An iron-built and armored vessel constructed to carry this additional weight, and of such extra dimensions as would be necessary if the same speed were to be maintained, draught of water preserved, and coal carrying capacity maintained, would have to be increased in size, displacement, and power as follows. The iron ship would have to be constructed: Length, 260 ft.; breadth, 55 ft.; displacement, 5,200 tons; coal to be carried, 750 tons; power, 5,000 horses; while the steel vessel, with steel-faced armor, as already described, would be: Length, 240 ft.; breadth, 50 ft.; displacement, 4,200 tons; coal to be carried, 650 tons; power, 4,500 horses. It would involve 1,000 tons additional displacement, and 500 additional horse-power to get in the iron ship equal speed and shot-resisting power, and she must carry 70 tons additional coal to enable her to travel an equal mileage without recoaling.

ON THE PECULIARITIES OF STEEL PLATES SUPPLIED FOR THE BOILERS OF THE IMPERIAL RUSSIAN YACHT, LIVADIA.

By Mr. W. Parker, Chief Engineer Surveyor of Lloyd's.

This paper, of which we give an abstract, as was to be expected, attracted great attention, and the hall was crowded. It is to be regretted, however, that no representative of Messrs. Cammell, of Sheffield, the makers of the plates in question, was present. Mr. Parker began by calling attention to the steady increase in the employment of steel for boilers, and then went on to two points open to doubt, namely, the rate of corrosion of steel plates, and, secondly, the chance of meeting with brittle plates. On the latter point he might state, on his own experience and on the authority of all the engineer surveyors of Lloyd's, that not one single instance of a brittle steel plate had come under their notice during the manipulation of 17,000 tons of steel; and it was not until the peculiar behavior of the plates of the Livadia's boilers occurred that they had any fear on the score of brittle plates. During the construction of steel boilers much was heard of mysterious fractures in steel plates which had stood all the tests required, been riveted up into their places, and had then, as it was termed, cracked without being touched. A great number of these cases had been investigated, and in every instance they had been clearly traceable to improper manipulation of the material, and the plates in the vicinity of the fracture were found to be perfectly ductile after the fracture had relieved the strain upon the material. These cases were quite as numerous in steel manufactured by the Siemens process as by the Bessemer process. They were clearly shown to be due to internal stresses set up in the plates by improper manipulation, and under certain conditions a tearing action was set up.

The fractures of the steel used in the boilers of the Livadia were entirely different from anything they had previously had experience of, and they had still later experience of other steel behaving in the same way, and he thought the time had come when steel makers must sift the matter to the bottom, and not only find out the cause, but find out the remedy. He then went on to say that he had obtained every facility for testing the plates of the boilers of the Livadia and obtaining other information concerning them. It appears that the plates were specified to be Messrs. Cammell's sub-carburized steel, made by the Siemens process, each plate to have a tensile strength of not less than 26 and not more than 30 tons per square inch, with an ultimate elongation of 15 per cent. in a length of 6 in. In all there were 154 plates supplied, and from these 219 pieces were cut for bending tests; the cold bending and temper tests were made—and were nearly all satisfactory when made—from the rough shearings, and in those cases where the rough sheared pieces broke before bending to the required curve, duplicate test pieces were planed and properly prepared, when they all proved to be satisfactory. There were also fourteen tensile tests made at the works, the tensile strength varying between the limits of 26·1 and 28·3 tons per square inch, the elongation in 8 in. varying from 27·3 to 34·3 per cent. The tabulated results of these tests, supplied by Messrs. Elder & Co. and Messrs. Cammell & Co., are set forth in the tables. On the arrival of the plates at Glasgow, Messrs. Elder, for their own satisfaction, had some check tests made, which practically corroborated those previously made at the steel works. The Livadia, it may be mentioned, was intended to be fitted with eight double-ended and two single-ended cylindrical boilers, each 14 ft. 3 in. diameter by 16 ft. long and 8 ft. 6 in. long respectively, constructed to work at a pressure of 70 lb. per square inch, the shells being of steel and the internal portions of iron. The shells were ¾ in. thick, made in three courses of plating—lap-jointed, treble riveted in the longitudinal seams, and double-riveted in the circumferential seams, as shown in Figures 2 and 4, and would be eligible, by the rules of Lloyd's Register, for determining the safe working pressure in marine boilers, to work at a pressure of 75 lb. per square inch. The plates were all punched, the holes being about $\frac{1}{16}$ in. less diameter than that of the rivets, then slightly heated and bent to their required curvature, and afterwards put together and the rivet-holes rimed out fair to the finished size in place. While under this treatment one of the plates accidentally fell from the slings on to a piece of metal, which indented it considerably, but did not crack or injure it in the vicinity of the indentation, but it was observed that the plate had cracked at a number of the rivet holes. Messrs. Cammell were, in consequence, communicated with, and Mr. Alexander, their representative, who examined this plate, gave it as his opinion that the plates had all been injured by punching, and should be properly annealed to restore the material to its normal condition. Accordingly, the plates were all sent to the maker's works at Sheffield and annealed in a furnace which had been specially altered for this purpose. The plates were afterwards returned to Glasgow, and riveted up in their places, and the boilers completed without any further cause for alarm. On subjecting the first boiler to hydraulic pressure, before the test pressure of 140 lb. per square inch was reached, the boiler shell tore asunder in three places, the cracks appearing to have started among the rivet holes of the longitudinal seams, and to have extended at the back of the rivet holes across the plate. In the second boiler, which it was intended to test, the shell plates were found to be cracked in a similar manner behind the rivet holes, before any water had been put into the boiler. Mr. Bryce, the manager of the engineering department of Messrs. Elder's works, at once gave instructions to cut the whole of the steel shells from these boilers, and they were replaced by others made of steel manufactured by the Steel Company of Scotland. These plates, which were worked in precisely the same manner, gave no special trouble in working, and the boilers proved to be satisfactory under test. On examination of the cracked or torn shell plates they were found to be extremely brittle; large pieces were easily broken off by one blow from an ordinary sledge hammer. In other words, here was a material which had satisfactorily withstood all the mechanical tests recognized by Lloyd's Registry, the Admiralty, and the Board of Trade, as sufficient to determine its suitability for the purpose for which it was being used, and was now shown to have become as brittle as cast iron, or even more so, after having apparently undergone only the working usual in boiler making. Chemical analysis was resorted to as being likely to throw some light on the subject. They do not show any reason why the material should behave in an anomalous manner.

Mr. Kirk, of Messrs. John Elder & Co., was the first speaker. He said he had been asked by Mr. Parker to make some tests, and he had done so. The first thing which came out was that the plates would bear very little manipulation. A strip about a foot long, slightly bent, would not bear straightening cold by gentle pressure. It cracked at once; but when heated and forged into a bar ⅝ in. square, it was so much improved that the bar could be bent cold on itself, so he thought that the material was good, but the manufacture bad. He then took some Siemens-Martin plates and tried to spoil them; he could injure them, but not make them as bad as the Livadia plates. Annealing might improve or spoil plates, according to how it was done. He showed a sample strip of the original metal bent cold on itself without crack. A second sample, equally good, had been left in a forge furnace for twelve hours, the damper being down, and the air excluded; the plate was uninjured. Two other samples heated in much the same way, but with the doors open and dampers up, so that a current of air passed through the furnace, were spoiled. A good plate could not be improved by annealing.

Mr Thorneycroft said that if they would look at the drawing of the annealing furnace they would see that the plates had been so stacked on each other that uniform heating was impossible. The more work was put into steel the better. He used large quantities of thin steel—$\frac{3}{16}$ in., and it was usually tougher and better than thicker plates.

Dr. Siemens, who spoke next, succeeded in attracting no small attention by making a most extraordinary statement. It is well known that he is rather given to surprising his hearers, and he must have been satisfied by the expression of blank amazement with which those present heard him assert that annealing steel plates did them no good. He began by saying that the performance of the Livadia plates was so extraordinary, that he had asked for and obtained a sample for analysis. He could break the plates up with a hammer The chemical composition was extremely irregular; and Mr. Parker had omitted all mention of one element, silicon, which was present to the extent of 0·03 per cent. Phosphorus was twice as great in quantity on one side of the plate as on the other. How did that come about? Was the ingot al

of the same metal? He was forced to conclude that the treatment which the ingot received greatly injured the metal. Mr. Kirk had explained how steel could be "burned." He should like to know how much oxygen had been absorbed by the Livadia plates. As for annealing, mild steel should not be annealed. It ought to be able to bear punching without any loss of strength, and should not require annealing. On the contrary, it was well known that punching increased the tensile strength per square inch of mild steel. This material ought to stand any kind of rough treatment cold. If it was heated and forged in any way, however, it might be annealed with advantage. If the metal was weakened by punching it ought to be rejected. His experiments showed that whenever mild steel was squeezed in any way, as by the action of a punch, it became stronger. He had no sympathy with annealing after punching. Much information was wanted as to the size of the Livadia ingots. If they had been allowed to stand all night in the fire the steel made from them was open to great suspicion. The annealing of steel plates ought to be done a plate at a time, not heaped on one another as shown in the drawing.

Mr. Martell held that while steel was better than iron, it would be foolish to shut our eyes to the fact that mysterious failures do occur. There was a mystery about mild steel which there was not about iron. The size of the ingot had a great influence. One steel manufacturer had tried to roll plates out of steel slabs, and had entirely failed. Mr. Webb, of Crewe, a man of great experience, said he could not get a sound plate from an ingot less than 24 in. square. That was an important statement. He could not restrain the expression of his astonishment at Dr. Siemens' assertion that punching did not weaken steel; it was contrary to all experience. Steel makers must not delude themselves by testing planed and filed samples, but rough samples, showing how the metal was handled in the shipyard. Confidence had been shaken, and must be restored by the steel makers.

Mr. White cited a case in which the manufacturer of some 2 in. deck armor plates tried to roll them from cast steel slabs without success. A plate might be worked too much. He had met with brittle $\frac{3}{8}$ plates, which were made tough by annealing. Beams as much as 65 ft. long, rolled in one piece, were sometimes found to be brittle at one end. He had every confidence in steel, but the makers must be cautious. Punching injured steel, notwithstanding Dr. Siemens' assertion to the contrary, 28-ton steel became 27-ton or even 26 ton steel after punching. Tests now made were not rough and severe enough.

Mr. Pearce said that Dr. Siemens' assertions were contrary to all experience, and he could not accept them. Punching injured steel, and they must anneal after punching. This was also specially true of plates any portion of which had been heated even slightly, as, for example, if a small corner were put in the fire. But all boiler plates ought to be drilled, and Messrs. Elder now did so treat their boiler plates. For every steel plate which had failed it should be remarked that twenty iron plates had done the same.

THE HYDRAULIC MACHINERY APPLIED TO OPERATING THE LOCK GATES OF THE DES MOINES RAPIDS CANAL.*

BEFORE proceeding with my subject proper, it will be necessary to give a general description of the Des Moines Rapids of the Mississippi River, the canal, locks, and approaches.

Time will not permit of a full discussion of the geological and hydrographic features of the Rapids.

The report of the Chief of Engineers, U. S. Army, 1867, contains a very clear and exhaustive treatise touching upon both these topics, written by Gen. Wilson, at that time the officer in charge. The theory advanced by Gen. Wilson is particularly interesting as affording an explanation of the causes operating to form the rapids. Briefly, it is this: An extensive lake covered the broad low grounds just above the present head of the rapids, during a comparatively recent geological period. The upper surface of this lake, at a level 105 feet above the present low water stage of the Mississippi, and maintained at such level by the rocky barrier, now partially cut away by the action of the water, assisted by ice and other unknown *geological* agencies; also that this wonderful erosive action has now ceased or is perhaps still carried on to an imperceptible extent; such rock as remains, forming a natural submerged dam entirely across the river, and extending from Montrose to Keokuk, a distance of 11 miles, the upper surface sloping about 22 feet.

As early as 1836 Robt. E. Lee, then a lieutenant in the corps of topographical engineers, made a survey of the Des Moines Rapids, and in 1854 and 1878 Gen. G. K. Warren made careful and complete surveys of the river in this locality. The earlier surveys of Lee and Warren resulted in the work carried on by the government at the most dangerous points in the reefs of rock obstructing the old steamboat channel. The nature of the work then accomplished was such that it could not be utilized in the present scheme for improvement.

Major Amos Stickney, Corps of Engineers U. S. Army, the officer in charge of the Des Moines Rapids Improvement and the Des Moines Rapids Canal, in his report to the Chief of Engineers for the fiscal year ending June 30, 1880, alludes to the present condition of the work and the amount expended thereon, as follows:

"The present project for this improvement was adopted July 19, 1867, the object being to secure a channel over the rapids, navigable at all times, with five feet depth at the extreme low water stage of the river. This has been essentially secured by the construction of a canal along the west river bank, from the city of Keokuk, Iowa, to the village of Nashville, Iowa, a distance of 7·6 miles, and open cuts through the chains and patches of rock from Nashville to Montrose, Iowa, a distance of about 3·5 miles. The canal is 300 feet wide, with the exception of a little less than 2 miles of its length, which is 250 feet wide.

"The open cuts when finished are to be 200 feet wide. The natural channel over the rapids was extremely narrow, crooked, and difficult to navigate even at medium stages of water and was utterly impassable at extreme low water for boats of ordinary size; and even lumber rafts were often broken up and a large part of them lost in making the passage. The amount expended to June 30, 1880, is $4,306,495.06 for construction of improvement; . . . and has resulted in essentially completing the canal, and making a fairly passable channel above the canal."

The Canal, Locks, and Gates.—The extract just quoted from Major Stickney's report shows the canal to be 7·6 miles long and 300 feet wide, with a depth at the extreme low water stage (1864) of 5 feet.

It may be added that the maximum range between high and low water stages in the river is at the lower lock 21 feet, and at the guard lock 11·6 feet, while the total lift which has to be overcome by the locks, at a low water stage, is 18·75 feet, of which the lower lock has 10·75 feet, and the middle lock 8 feet.

The three locks are located as follows: The lower lock at Keokuk, the middle lock 2½ miles above, and the guard lock at Nashville, the upper terminus of the canal.

The top of the canal embankment is carried to a line 2·2 feet above the high water stage of 1851 (the highest stage of which there is record), making the height of embankment at lower lock, 26 feet above the grade of the excavated channel below the lower lock; and at the guard lock 19 feet above grade.

The embankment is 10 feet wide at the top, the slope wall protecting the sides having a thickness of 18 inches, and an inclination of 1¼ to 1 and 1½ to 1 on the canal and river faces respectively.

The top is covered with macadam, but at the date of this article the stone protection on the sides and top are only partially completed, the slope wall, for the most part, being carried only a few feet above the ordinary water level.

The locks are each 350 feet long between the centers of hollow quoins, and 80 feet wide. The thickness of the lock wall at base is 10 feet, but the wall gains additional stability from the masonry of the culverts for filling and discharge which extends for nearly the entire length of the lock, and heavy buttresses are constructed at points not reached by the culvert masonry. The inside face of the wall has a batter of half an inch to 1 foot, the height of lock wall above lock bottom varies of course at the three locks, that of the lower lock wall being 23·5, with a width across the top of 6 feet.

The openings for the supply of water to the main filling culverts are four in number on each side of the lock, being situated in the masonry of the upper recesses for the lock gates, the dimensions of each opening being 3 ft. × 5 ft. 10 in. The main culverts extend along the back of the lock wall, diminishing in area as they proceed, and discharge into the lock chamber through eight openings each 3 ft. × 3 ft. 8½ in., which are arranged at regular distances along the length of the lock wall.

The culverts for emptying the lock, take the water from openings in the lower recess walls, similar to those for the filling culverts, and discharge through the wing walls below the lock chamber, by five openings, each 3 ft. × 5 ft. 10 in. The culverts are provided with ventilating pipes, which permit the escape of compressed air.

The miter sills for the lock gates have an inclination upstream, between the hollow quoins and apex, of 21° 14′ 30″. The width of miter sill at apex 16 ft., the down-stream side curving with a radius of 100 feet; the voussoirs composing the arch, and the face stones on the up-stream side are very carefully fitted together, and are bolted to the bed-rock by bolts 1¾ in. diameter, secured 2 feet deep in the rock by wedges and sulphur cement. The face stone used in the construction of the locks is hammer dressed; the joints not to exceed ¼ in. in thickness. The backing stone, rough, *i. e.*, within certain limits, as the joints must not exceed 1 in. in thickness.

The stone used is magnesian limestone, principally from Sonora Quarry, Ill., which is located on the river opposite the canal, and hence within easy access by barges, at ordinary stages of water. The greater part of the cement used in building the locks was Clark's Utica cement, which proved to be a very good article.

Lock Gates.—The lock gates are in pairs, each gate being a trifle over 45 feet long and 3·75 feet thick through the center. The timbers composing the up stream side of each gate are curved with a radius of 137 feet on their exterior faces, and are compound, built up of four courses, each 3 × 12 in., giving a total thickness of 12 inches, except the timbers at the bottom of the gate, above and below wicket openings, which have a total thickness of 14 inches. The spaces between all but these lower timbers measure 12 inches. The straight timbers on the down-stream side of gate are solid, in one length, and of the same size as the compound timbers. The tow post is 20 × 24 in., the ends of both straight and curved timbers being mortised therein, and secured at the other end to a heel post of cast iron which bears against a hollow quoin also of cast iron. The straight timbers are trussed on the down-stream side by wrought iron rods carried over a saddle timber at the center of gate, the ends being secured to tow and heel posts. The gates are covered with 3 inch plank, and contain water compartments which assist in counteracting the tendency of the gates to ride up under a full head of water. The gates bear against a cushion stick 12 × 12 in., fitting in a rabbet cut in the coping of the miter sill.

The gates are suspended from the tops of heavy cast iron columns 18 inches diameter by two wrought iron rods, one of which is attached to the bottom of the gate at the tow, the other at the center; the rods being respectively 1¾ and 2¼ in. in diameter. The columns from which the gates depend are secured by four guy rods, whose lower ends are anchored in the masonry of the lock wall. All the timber and planking used in the construction of the gates is of oak, which was first subjected to a boiling or steaming process in a large tank, the object of this being to free the timbers from sap.

Between the two lower timbers on the gates are situated six openings, each 2¼ × 3 ft., and covered by pivoted cast iron gates. These gates are controlled from above by an arrangement of rods and levers, and can be used to operate the lock in case of accident to the culverts.

To Major Amos Stickney's corps of engineers, U. S. Army, is due the credit of originating the plan for operating the lock gates by hydraulic pressure, as at present employed on the Des Moines Rapids Canal. This plan was approved by a board of engineers convened at Keokuk, May 10, 1875, and during the month of August in that year under direction of Major Stickney, I assumed charge of the construction of the machinery and erection of same. Messrs. Sample, McElroy & Co., of Keokuk, Ia., obtained the contract for furnishing the material and labor required to construct the machinery, at specified rates. As soon as the details were worked out sufficiently far to warrant a beginning, the preparation of patterns and the castings therefrom was commenced.

After a cessation of work for over six months in 1876, the work of erecting the machinery at the middle and lower locks was finally completed, and the canal opened for navigation August 22, 1877.

The general plan of the machinery in use at each of the three locks is this: A steam pumping apparatus distributes water under high pressure to eight hydraulic cylinders, four of which operate the culvert and four the lock gates.

The central figure, then, of the whole system is the engine-house, containing, as it does, the steam pump and the distributing valve, by means of which the cylinders are operated, singly or in pairs; the machinery is thus under the perfect control of one man, the engineer, who, from his position in the house, responds to the signals of the lock master stationed at the lock wall.

Engine-Houses.—The buildings are substantial structures, specially designed for the purpose in view. The material used in their construction is magnesian limestone for exterior walls and brick for partition walls, the former being 18 inches and the latter 8 inches thick. Outside dimensions of house, 27 feet 4 inches by 27 feet 4 inches.

The ashlar work cut with rock face, the trimmings including cornice arch stones, steps, etc., cut with various alterations of rock face — margin draught, or tool and hammer dressed work. The roof is covered with extra heavy Lehigh slate, terminated by a copper gutter, which rests directly upon the stone cornice and forms the upper member of same. There is no exposed woodwork on the outside of the building, except such as necessarily occurs about window and door frames.

The foundations for exterior and partion walls and for the piers supporting the engine, boiler, and chimney are built of rubble stone laid in cement, and they rest on the solid bed rock, at a distance of from 17 to 19 feet below the level of the rock coping. The main floor is from 4 to 6 feet above the rock coping, and the height of story 11 feet in the clear. On a level with the main floor, and located in the engine room, is the steam engine and distributing valve; an adjoining room contains the boiler, and next to that is the coal room.

The floor of boiler room is fire-proof, consisting of groined brick arches overlaid with concrete.

The basement contains the pump, connecting with the engine on the floor above, and a cistern; also a small store-room and an ash-vault.

The cistern receives water from the canal, which, after undergoing a filtering process, passes into a storage compartment, from whence it is used to supply the boiler and pumps.

The boiler used to supply steam to the pumping engine is of the upright tubular form, the shell being 50 inches in diameter, and the height 7 feet. The boiler rests upon an octagonal base of cast iron, the rim of this base also serving as a support for the grate. Shell of boiler, five-sixteenths of an inch thick, of United States tensile strength iron; heads, half an inch thick, of best charcoal flange iron; shell single riveted. The flues are 91 in number, being 2¼ inches in external diameter and 4 feet 9¼ inches long between heads. Diameter of fire-box, 3 feet 8⅜ inches, with a height above grate of 2 feet.

The water-space between the shell and fire-box sheet is 2½ inches, the connection between the two at bottom being made by a ring of cast iron.

Heating surface of flues, 255 sq. ft., and of fire-box 21 sq. ft., making a total of 276 sq. ft. of heating surface. Grate surface, 9 sq. ft.

The draught connections consist of a funnel-shaped bonnet inclosing the upper head of boiler and reducing where it connects with chimney to 18 inches diameter. The chimney flue is 24×24 inches, and into this is conveyed the exhaust steam from the engine.

Boiler.—The boiler is provided with 12 brass cleaning plugs, steam gauge, gauge cocks and glass water gauge, blow off cock, safety valve, and a steam whistle for signaling steamboats. The boiler is connected with the main pump, and has independent water supply in the shape of a No. 15 Hancock Inspirator, drawing water directly from the cistern. The glass water gauge, inspirator, steam gauge, and the hydraulic gauge connected with the pump are all placed in the engine room in plain sight of the engineer.

Fuel.—The fuel used is bituminous coal from Iowa and Illinois. That from the Seville mines, Illinois, has, I think, given the best results of any coal yet tried. The average consumption per 24 hours is about 12 bushels, at a total cost of $1.32.

The maximum working pressure is 80 lb. per square inch, and the boilers were tested after being warmed up, with 150 lb. per square inch water pressure.

Pumping Engine, etc.—The pumping apparatus for supplying pressure to the hydraulic cylinders consists of an upright steam engine stationed on the main floor of the engine house, the frame extending down into the basement where it is bolted to a heavy masonry pier. To the lower part of the frame is attached a double acting piston pump, the rod of which is a continuation of the piston rod of the engine, extending through the lower head of the steam cylinder and slightly diminished in size.

The piston rod proper is connected with a fly wheel shaft carried on the upper part of the frame. Steam cylinder 12 inches in diameter by 12 inch stroke, pump cylinder 6 inches in diameter by 12 inch stroke, the respective areas being 113·09 square inches, and 28·27 square inches, or in a proportion of four to one. Engine is furnished with fly wheels, governor, self-feeding oil cups; and every appliance to save the time and close attention of the engineer, who is thus enabled to devote himself particularly to the distributing valve.

The valves in the pump at the guard lock are of hard rubber, but at the other locks they are of composition metal, and consist of eight receiving and four delivery valves, each covering an opening three inches in diameter. The suction pipe is six inches in diameter, and the discharge four inches; with the latter is connected a relief valve, and the system of pipes which constitute a protection against fire. These pipes branch soon after leaving the engine house, one of them crossing the sluice and being provided with hydrants, one in the vicinity of each of the workshops. The most important connection of the pump is with a distributing valve, which will be hereafter described.

The lift of the pumps varies from 9 to 13 feet, and the working pressure that is required to operate the gates varies from 75 to 200 lb. per square inch, dependent on the change of water in the canal and river. The vacuum and pressure chambers are wrought-iron cylinders, the ends being stayed with four three quarter inch rods.

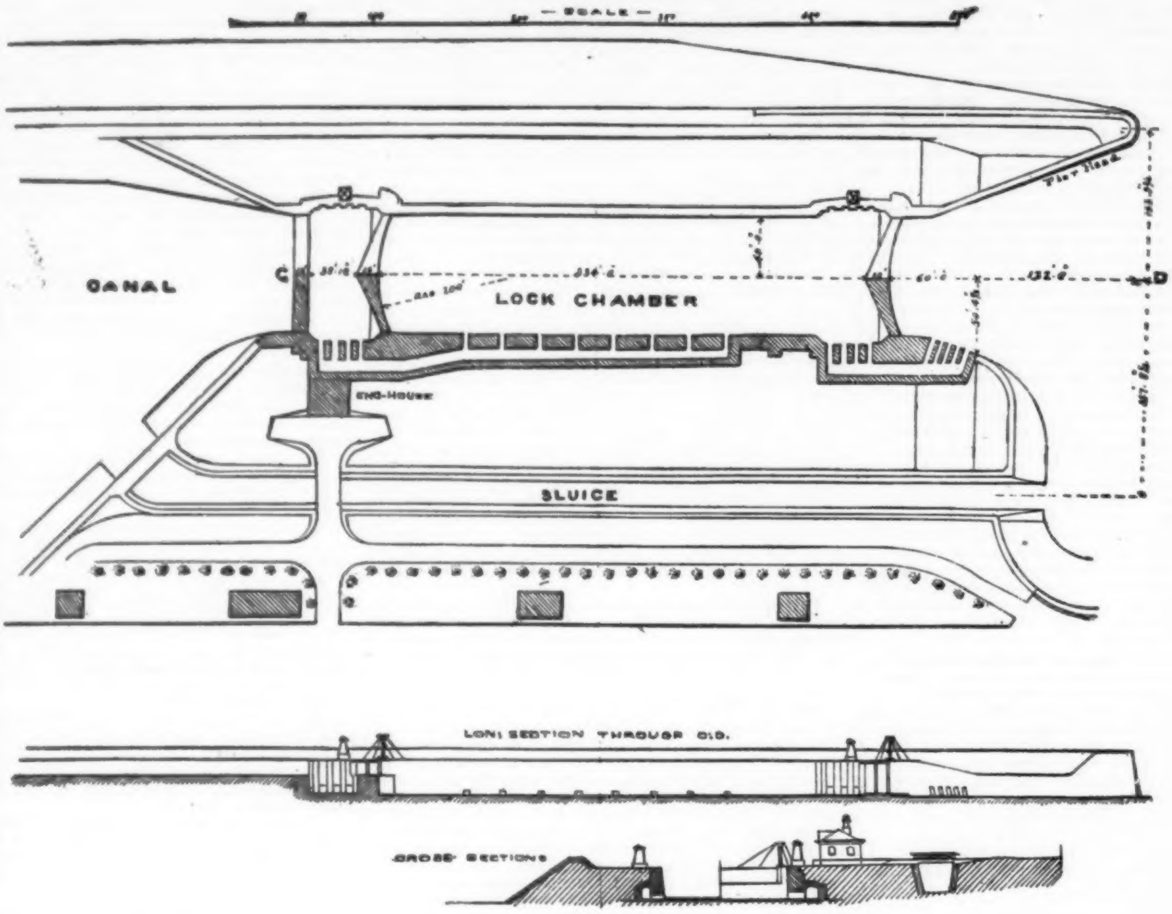
The pumps can maintain a pressure of 300 lb. per square inch, if it should ever become necessary to do so.

Distributing Valve.—The distributing valve is a device for directing the pressure derived from the pumping engines, to the cylinder or cylinders which it is desired to operate.

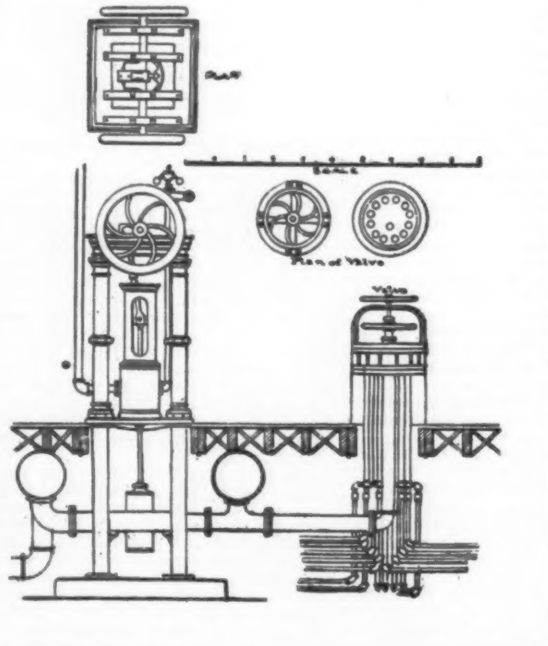
A detailed description of this valve would prove too lengthy for insertion in this paper, but the main features may be given. The valve casing consists of a strong cast iron cylinder with heads, the lower head being perforated with ports connected with the pipes leading to the various hydraulic cylinders. Over the ports in the lower head is a

* A paper read before the Western Society of Engineers, Feb. 1, 1881, by R. Ralston Jones, Assistant Engineer Des Moines Rapids Improvement.—*American Engineer.*

HYDRAULIC MACHINERY, OPERATING GATES — OF THE — DES MOINES RAPIDS CANAL.



PUMPING ENGINE AND DISTRIBUTING VALVE.



ENGINE HOUSE.

circular plate of brass with three ports, and carrying on its upper surface an ordinary D valve.

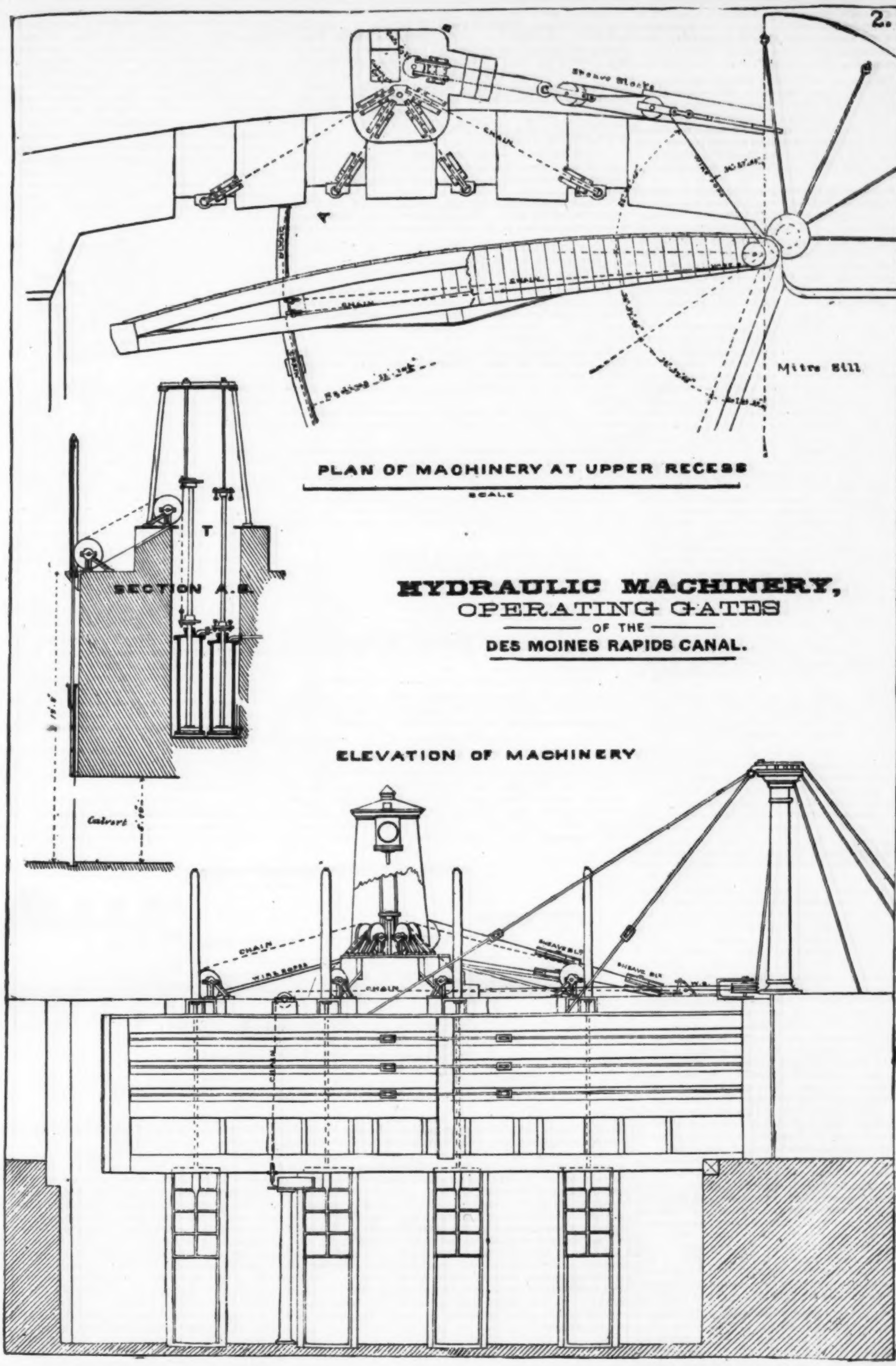
The plate and D valve are revolved independently of each other, the one by a solid stem and the other by a hollow stem fitting loosely over the first, both stems projecting through the upper head of valve casing, and the egress of water from around the stems being prevented by the use of packing glands. Each stem is provided with a hand wheel for turning it in any direction, and an index plate and pointer shows the proper position which the valves should occupy in order that any particular pair of cylinders may be operated. The cylinders are ordinarily operated in pairs, but in the event of an accident occurring to a cylinder on either side of the lock, its mate can be operated independently by simply shutting a stop cock with which each pipe leading out of the basement is provided. The general principle which governs the operation of the distributing valve is the same as that shown in an ordinary steam engine provided with a D valve, viz., that of supply and exhaust through alternate ends of the hydraulic cylinders, the consolidation effected by the large valve, however, enabling it to perform the duty of eight separate valves, if such were attached directly to the hydraulic cylinders. The pipes connecting the valve with the hydraulic cylinders are laid four and a half feet underground, as a protection against freezing; they are of wrought iron two inches in diameter, and connected by patent sleeve couplings.

The pipes were carefully tested after being laid, no connections being accepted which failed to stand a test of 375 lb. per square inch water pressure.

The pipes crossing the locks are laid over the breast wall above the upper recess, and a system of three way cocks at this crossing enables them to be thoroughly drained. The cylinders are also provided with drain cocks, so that they can be emptied in the winter season.

Cylinders, Sewers, etc.—The eight hydraulic cylinders which at each lock operate the gates, are arranged in pairs, each pair consisting of one culvert and one lock gate cylinder, placed in a pit inclosed by heavy masonry, directly back of each recess wall.

Culvert cylinders 16 inches diameter by 6 feet stroke; lock gate cylinders are of two sizes; those for the lower or largest gates having a diameter of 16 inches, while those operating the upper or small gates are 9 inches in diameter, the stroke in each case being 5 feet 10 inches. The bases of these cylinders are securely bolted to the masonry on which they rest, and are also secured by heavy cast iron brackets bolted to the side walls of the pit.



HYDRAULIC MACHINERY, OPERATING GATES OF THE DES MOINES RAPIDS CANAL.

The thickness of the shell of cylinder 1 inch, and of heads and bases 1½ inches, with ground joints. The ports for supply and discharge are located in the heads and bases, nearly in the center of the cylinder, and are 2 inches in diameter.

The pistons are of cast iron, and are provided with double crimped leather packing half an inch thick, with a brass separating plate between each set of leathers. Leather is also used for packing around piston rods.

The piston rods are of wrought iron, solid; for the culverts being 3½ inches, and for lock gates 3 inches diameter; length, 17 inches, and secured to pistons by being screwed therein, the rods prevented from turning out by a steel pin passing through the piston. Each rod carries two crossheads secured by keys.

The lower crosshead, in the case of both culvert and gate cylinders, being connected by means of adjustable eyebolts with the chains or wire ropes used in opening the said gate, while the upper crossheads are connected with the wire ropes for shutting the gates. The cross heads slide over rods 2 inches in diameter which serve as guides, the lower end of these guides being made fast to lugs cast on the cylinder head, while the upper ends pass through a plate resting on the columns of the tower above the pit, and are secured by nuts, thus forming a continuous and rigid connection between the cylinder and top plate of tower.

A base of dressed stone masonry is built above the walls of the pit, commencing on a level with the lock coping and extending to a height of 3 feet above. This base is surmounted by a plate of cast iron, provided with suitable openings for the passage of the piston rods, chains, etc., and carrying for the culvert four and for the lock gate two double grooved shears, supported on heavy pedestals bolted to the plate.

The base plate is supported over the opening of the pit below by wrought iron beams, and is secured in place by eight straps of wrought iron anchored in the solid masonry beneath. Four of these straps are placed vertical, the other four diagonally, to resist the resultant of the up and side strains.

Resting upon and bolted to the base plate is a gallows frame, consisting of four inclined columns of cast iron, supporting a strong cast iron plate through which the upper ends of the guide rods pass, and to which they are secured. This frame is inclosed by wooden sides made in four sections for convenience of removal, and provided with windows for lighting the interior, and a door which gives access for the purpose of oiling the machinery, etc.

Having followed this general description as far as it applies to both cylinders, it will be more convenient hereafter to describe the connections of each separately, commencing in each case at the lowest point of attachment in the lock and proceeding upward and toward the cylinder.

Culvert Gate Machinery.—The four culvert openings in each recess wall are covered by cast iron gates well ribbed, and sliding over cast iron frames secured to the wall, a cushion of oak plank being placed between the two. The bearing surfaces are planed perfectly true in order to reduce friction and prevent leakage. Attached to each culvert gate is a wrought iron rod 2½ inches in diameter, fitting in a socket on the upper part of the gate and secured in place by a split key.

To the upper end of this rod is attched a hollow stem of cast iron, the length of this stem being 9 feet, the outside diameter 6 inches, and thickness of shell half inch. A cross section through the stem is crescent-shaped, having a slot on one side extending for nearly the entire length of the stem, the ends of the stem terminating in heavy bosses. The object of this arrangement being to secure a central pull for all chains and wire ropes. The strains on the hollow stem are compressive only, the tensile strains being taken by the end of the wrought iron rod which ends through the boss.

On a level with the lock coping and bolted to the wall is a heavy bracket, which serves as a guide for the stem, and a partial support for the pedestals of a broad cast iron pulley or sheave whose diameter is in line with the center of the gate stem, or rather this sheave is so arranged that the axis of those portions of the chains and wire ropes which are vertical coincide with a plane projected through the center of the gate stem. The sheaves just alluded to are 24 inches in diameter, having a central groove for the ¾ inch chain used in raising the gate, and side grooves for the ⅝ inch wire ropes for shutting the same.

The chains are attached to the 2½ inch rod connected with the gate stem by a wrought iron stirrup fitting under the nut which secures the rod to the stem. The chain passes over the sheave just above described, and over a second sheave, which was alluded to previously as secured to the base plate of tower, and passing down is attached to the lower cross head by an adjustable eye-bolt. The wire ropes—one in each side groove—are connected to a bolt which passes through the boss on the upper end of the gate stem, the ropes passing under the sheaves and connecting with an eye-bolt provided with an equalizing pulley which is attached to the upper cross-head. Each cylinder controls four culvert gates, but as the points of attachment to the cross-head are arranged equidistantly with regard to each other, and the center of the piston rod, any pair of chains and ropes can be detached on opposite sides, and the balance being still perfect, two gates can be operated instead of four. (This is important in the event of an accident occurring to any particular gate.)

The pressure being applied to the cylinder through the upper part, the piston is forced down, tightening the chains, while paying out the wire ropes, thus raising four culvert gates. The reverse operation closes the gates.

Lock Gate Machinery.—The special devices for operating the lock gates are as follows: A segmental arch of cast iron placed horizontally extends between the miter sill and each recess wall, the curve being described with a radius of 32·792 feet from the center of the heel-post of gate. This arch is substantially a curved angle iron, its base resting on masonry built up from lock bottom, or (as is the case with the arches for upper gates) supported by iron columns, the top of the vertical rim being 2 inches below the bottom of gate. The arch is secured by bolts to the walls between which it springs, the ends being also provided with eye-bolts for securing the chain cables used in moving the gates. The cables lead through sheaves 12 inches in diameter, attached to the bottom of the gate in such a position that the length of the tangential pull remains constant throughout the entire movement of the gate.

The chains now pass upward and over a second pair of sheaves at the top of the gate, of the same diameter as the first (12 inches). A short distance back of these sheaves, the chain connects with a wire rope half an inch in diameter, which continues in a horizontal direction along the gate, passing around a set of sheaves 18 inches in diameter, which are attached to the heel-post.

The wire rope, on leaving the sheaves just mentioned, leads over the center of heel-post in a line perpendicular to the position of the axis of the gate when half open, by this means avoiding the wrap which would otherwise result from the movement of the gate. The wire ropes now enter a system of sheaves for reducing the length of stroke required of the cylinder. The reduction here effected is seven-fold. The stationary sheave-blocks of this system are secured by wrought iron straps to the lock coping, while the movable ones travel on rollers over inclined planes of cast iron.

The sheaves themselves are 18 inches in diameter, the frames of wrought iron separated by cast-iron plates.

To the tail-block is attached an equalizing sheave, around which passes a three-quarter-inch wire rope, and this rope, after passing over a 30 inch sheave on each side, is connected with the lower cross-head, the shutting rope passing under the sheave and connecting with the upper cross-head.

Pressure being applied to the piston of the hydraulic cylinder, one rope is tightened, causing the chain cable to bear against the arch or guiding circle situated in the lock below the gate, and the gate is opened or shut, as the case may be; the other wire rope moving the gate in a contrary direction.

Filling the Culverts at the Head of the Canal.—The original intention regarding the filling culverts and sluices was that they should be operated by hydraulic pressure, but it was ultimately deemed best, on account of the infrequency of their use, compared with that to which the lock culverts were subjected, to substitute machinery which could be operated by hand.

The filling culverts at the head of the canal are six in number, being rectangular openings, each 3 by 6 feet, through a breast wall of heavy masonry, built in the canal embankment immediately below the guard lock, and together constituting the feeder supply for the canal. The combined area of these openings is 108 square feet.

These culverts are covered by gates similar in design to those employed for the lock culverts.

The gates are controlled by a shaft connected with a double-geared crab or windlass, the shaft carrying a series of loose pinions which engage in racks connected with the gates.

By means of a simple device consisting of a clutch coupling working on a feather key and moved by a lever, any one of these gates or the entire number can be raised or lowered at will.

Sluices at Middle and Lower Lock.—At the middle and lower lock a sluiceway, 16·629 feet wide at bottom, is constructed parallel to the direction of the lock, for the purpose of taking the surplus water from the level above and discharging it below the lock. A breast wall crosses this sluiceway at the head, the width being greater at this point, and in the breast wall is situated a series of openings similar in every respect to the filling culverts at the head of the canal. These sluice gates are operated by means of a combination of bevel gears, one of which serves as the nut of a large screw attached to the gate.

General Remarks.—The maximum duty performed by each of the culvert cylinders at the lower lock is, in round numbers, 160,000 foot-pounds; that of the lock gate cylinder 50,000 foot-pounds.

Weight of the material composing each of the largest gates, about 55 tons. The length of time occupied in moving the various portions of the machinery is as follows:

Opening culvert gates, about........	1½ minutes.
Moving upper lock gates............	1¼ "
Moving lower lock gates	2¼ "

The usual time required in making a lockage at the lower lock during an extreme low water stage is ten minutes. This is counting from the time a steamboat is in the lock and her lines made fast until the lower gates are opened ready for her departure.

The quantity of water displaced in filling or emptying the lock chambers is about 2,250,000 gallons, or by weight, 9,371 tons.

The cost of the machinery at the three locks was nearly $60,000.

Such portions of the lock grounds as are not needed for other purposes have been laid out in grass plats and walks lined with shade trees.

A telephone along the entire length of the canal, and connecting with the main office, affords a means of notifying any of the locks of the approaching boats, so that delays are reduced to a minimum.

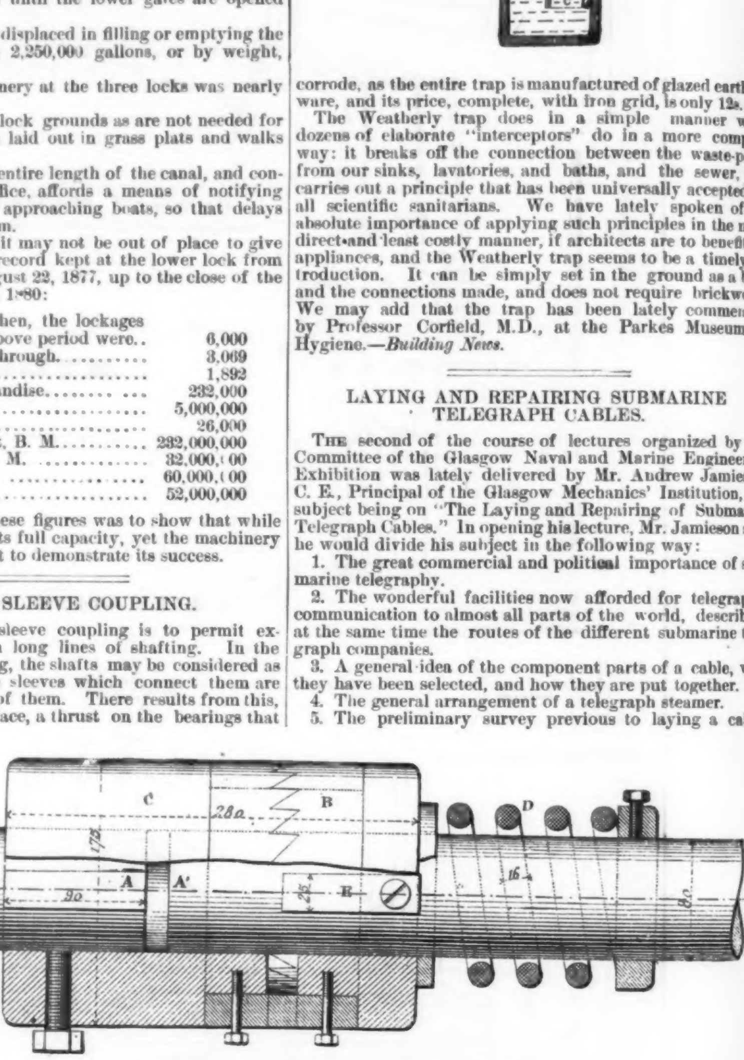
In closing this article, it may not be out of place to give a few extracts from the record kept at the lower lock from the time of opening, August 22, 1877, up to the close of the past season, December 1, 1880:

In round numbers, then, the lockages made during the above period were..	6,000
Steamboats passing through..........	3,069
Flats and barges	1,892
Tons general merchandise......... ...	232,000
Bushels of grain	5,000,000
Passengers...........................	26,000
Lumber rafts, in feet, B. M.	232,000,000
Log rafts, in feet, B. M.	32,000,000
Shingles	60,000,000
Lath	52,000,000

The object in giving these figures was to show that while by no means worked to its full capacity, yet the machinery has received sufficient test to demonstrate its success.

EXPANSION SLEEVE COUPLING.

THE purpose of this sleeve coupling is to permit expansion to take place in long lines of shafting. In the ordinary mode of coupling, the shafts may be considered as all of one piece, since the sleeves which connect them are keyed firmly to each one of them. There results from this, when expansion takes place, a thrust on the bearings that



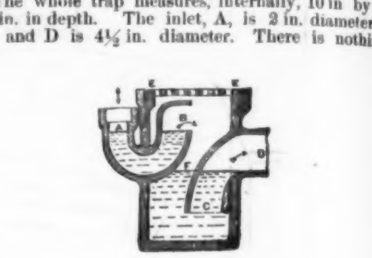
EXPANSION SLEEVE COUPLING.

tends to throw the shafting out of line. It was to obviate this difficulty that the present arrangement was devised. In the annexed figure, A and A', are two shafts, between which a small space is left, and which are connected by two sleeves, B and C, with teeth inclined according to the direction of the rotary motion. The sleeve, C, is keyed firmly on the shaft, A, and the sleeve, B, is, in the same manner, keyed on the shaft, A', but in such a way as to allow the latter to have a motion in a longitudinal direction. These two sleeves are held in constant contact by the spring, D.

It follows from this arrangement that the shaft, A', may expand or contract without in any manner affecting the revolving motion brought about by the sleeves. Through the arrangement of its teeth this coupling also lessens the effect of the end thrust, which occasionally takes place in transmissions. The invention is due to M. Goubet, of St. Denis, France.

A NEW TRAP.

MESSRS. JAS. STIFF & SONS, of Lambeth, are manufacturing a newly-invented waste-water trap, called the "Weatherly disconnector trap," which combines in a convenient and easily-accessible form a siphon trap, a waste-pipe, a grease trap, and an open yard gully, which we have pleasure in laying before our readers. It can be placed in any convenient position outside the house, wherever a waste-pipe discharges. The trap may be best described by the accompanying section. A B is a siphon or inlet into the outer end of which A, the wastepipe, is introduced. It has a deep water-seal, and the discharge end, B, is so turned into the gully that no dirt can clog the siphon, nor can the slop-water be forced up through the grating, E E. The end, B, is also made large enough to admit the hand, so as to remove an obstruction, should any occur. The exit pipe, C D, by its dipping into the gully, becomes a second trap, affording a good water-seal, and any gas from the sewer end, D, which may pass through the lower trap, finds an easy and constant escape through the open grating into the air, so that double security against effluvium is obtained by this means. Grease finding its way into the trap will float on the surface of water, F, and can be removed by taking off the iron grating. It will be seen that the Weatherly trap is simple and effective in operation; it contains nothing likely to get out of order; there is no chance of its overflowing; the double trap and open grating are both safeguards against the admission of any sewer air into the house, and as the traps are distinct and independent, the foul gas can exert no pressure on the inner and upper siphon. As we have personally inspected the trap, we can safely recommend it to the profession as an economical substitute for other costly and elaborate contrivances designed to effect the same object. The whole trap measures, internally, 10 in by 9 in., and 16 in. in depth. The inlet, A, is 2 in. diameter, B is 3¼ in., and D is 4½ in. diameter. There is nothing to



corrode, as the entire trap is manufactured of glazed earthenware, and its price, complete, with iron grid, is only 12s. 6d.

The Weatherly trap does in a simple manner what dozens of elaborate "interceptors" do in a more complex way: it breaks off the connection between the waste-pipes from our sinks, lavatories, and baths, and the sewer, and carries out a principle that has been universally accepted by all scientific sanitarians. We have lately spoken of the absolute importance of applying such principles in the most direct and least costly manner, if architects are to benefit by appliances, and the Weatherly trap seems to be a timely introduction. It can be simply set in the ground as a box, and the connections made, and does not require brickwork. We may add that the trap has been lately commended by Professor Corfield, M.D., at the Parkes Museum of Hygiene.—*Building News.*

LAYING AND REPAIRING SUBMARINE TELEGRAPH CABLES.

THE second of the course of lectures organized by the Committee of the Glasgow Naval and Marine Engineering Exhibition was lately delivered by Mr. Andrew Jamieson, C. E., Principal of the Glasgow Mechanics' Institution, his subject being on "The Laying and Repairing of Submarine Telegraph Cables." In opening his lecture, Mr. Jamieson said he would divide his subject in the following way:

1. The great commercial and political importance of submarine telegraphy.
2. The wonderful facilities now afforded for telegraphic communication to almost all parts of the world, describing at the same time the routes of the different submarine telegraph companies.
3. A general idea of the component parts of a cable, why they have been selected, and how they are put together.
4. The general arrangement of a telegraph steamer.
5. The preliminary survey previous to laying a cable, with a description of Sir William Thomson's sounding machine.
6. The mode of laying the cable.
7. Faults, how they occur, and how they are localized.
8. The repairing of a faulty cable, with the difficulties encountered, and how best they are overcome.

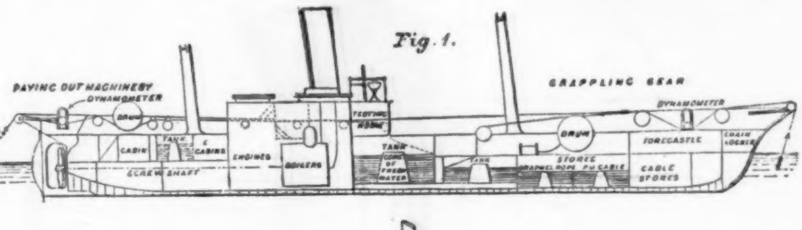
The commercial importance of submarine telegraphy was, he said, at once apparent when it was understood that at the present moment there were cables lying at the bottom of the ocean of the total value of about £30,000,000, those owned by private companies—seventeen in number—being of the value of about £26,000,000. The principal companies were the Anglo-American, the Eastern and South African, and the Eastern Extension, so admirably and successfully managed by Sir James Anderson. Referring to the political importance of such cables, he said that it arose from the fact of governments—more especially the British Government—being able to issue orders to their fleets and armies from headquarters, as well as to arrange matters connected with colonies and different governments in a manner and in a space of time that would have been utterly impossible a few years ago. A special and very pertinent example was seen in the case of the Boers in South Africa. By means of a large Mercator's chart of the world, on which all the principal cables were laid down in white, the lecturer was enabled to indicate what wonderful facilities were now offered for telegraphic communication to almost all parts of the world. A number of lines were specially described, beginning with those laid across the Atlantic, the last of which was completed last August, in the short space of twelve days. It was laid from Heart's Content, in Newfoundland, to Ireland, and it was the quickest and perhaps most successfully laid of all the Atlantic cables, for it was reported that not a single hitch occurred during the operation, to such a pitch of perfection had the engineers, electricians, and captains of the Telegraph Construction and Maintenance Company arrived by continued practice and by careful selection of the most approved appliances. That company had laid all the

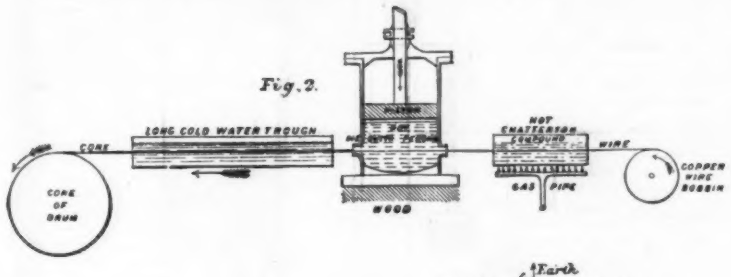
seven cables of the Anglo-American system, besides more than half of the other cables throughout the world. In the course of his description of those various submarine cables, Mr. Jamieson mentioned many interesting details, the result of his own long and varied personal experience, both in the Eastern and the Western Hemisphere; and at the close of his description he said it would be observed that it only required that a cable should be laid from San Francisco or Vancouver's Island to Japan, in order to complete the electric girdle round the earth, with Britain's hands on the buckle. Nine-tenths of all the vast network of the submarine telegraph system had emanated from the banks of the Thames, and the headquarters of all the large companies were to be found in and around that busy center of commerce, Old Broad street.

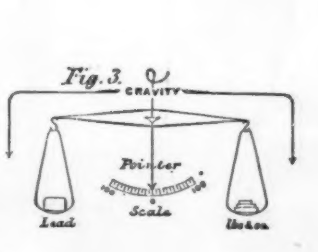
In proceeding to describe the composition of a telegraph cable, Mr. Jamieson dwelt with some detail upon the conducting medium and how the wires were put together, and upon the insulating materials used and how they were disposed so as to prevent the dissipation of the electric force. The conductor and its gutta percha covering together constituted the core of the cable; and lastly, there were the various kinds of sheathing materials. The manufacture of a cable through all its stages was most graphically described, and very fully illustrated by machinery, by numerous drawings and by a great variety of specimens. One of the diagrams (Fig. 2) illustrated in a most thorough manner all the stages of the manufacture, from the bare core, which first passed through a machine for serving tanned jute yarn; the yarn-covered core then passing through a machine for serving iron wire from a series of bobbins; and the wire-covered cable in its turn passing through a trough to get a hot coating of Clark's compound, then through a machine to give a double covering of Manila yarn or tape, next through another trough containing Clark's compound, and lastly being laid with great care and regularity in the cable tanks at the factory and "swabbed" down with silica wash. Among the specimens exhibited there was a piece of a cable capable of bearing its own weight on the bight,

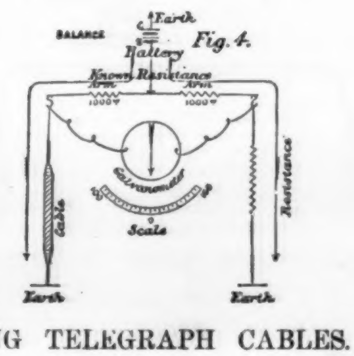
Construction and Maintenance Company. He showed it in operation, and spoke of it as the most perfect thing of the sort yet devised. It would bring up half a wineglassful of the material forming the sea bottom from almost any depth; indeed, it was experimentally shown that if let drop down on a table on which a piece of paper was lying flat it would pick it up as securely as a human being could do the work with his finger and thumb. The "ground" having been surveyed, plotted out, and properly selected, the shore end of the cable was landed, and a constant communication was maintained between the electricians left on the shore and those on board the steamer, so as to have the cable carefully tested for its conductivity and insulation resistance. All being right, the ship would set out on her expedition, every person on board having his own special work or duty to attend to—no hurry, fuss, or unusual excitement being permitted in a well-arranged cable-laying expedition. The various duties of the responsible members of the staff were graphically described by the lecturer, who remarked that the whole operation went on like clockwork until the opposite shore or landing-place was reached, when the same operation of landing the other shore-end took place, if it had not been done previously. When all was found to be electrically perfect, the health and prosperity of the cable was enthusiastically drunk, and complimentary messages flowed through at lightning speed.

In commencing what may be termed the second part of his lecture, namely, the occurrence, localizing, and repairing of "faults" in a cable, Mr. Jamieson said the causes of faults were as follows: 1. Total breakage due to abrasion, suspension between submarine eminences, insufficiency of "slack," volcanic eruptions or terrestrial disturbances, or possibly large masses of rock becoming detached and falling across the cable in their descent. 2. In shallow waters from ships' anchors. 3. Faults caused by teredos, or animal borers. 4. Break of the conductor, with perfect or good insulation. 5. Latent faults in the cable when laid, developing after a time; deterioration of core, joints, or sheathing. 6. Lightning. Each of these causes of faults









LAYING AND REPAIRING TELEGRAPH CABLES.

when new, at a depth of 2½ miles. It had been taken from a cable on which a repair was lately effected and which had lain in 2,000 fathoms of water for a period of ten years, probably the greatest feat yet done in cable-repairing by a single ship.

The cable, of whatever kind, having been made in the factory, and the cable-ship having been fitted up, she was brought alongside the wharf opposite to the factory, so that transportation from the factory to the tanks in the ship might be made; and at this stage the lecturer stated that a thorough system of electrical testing was constantly kept up during the whole process of manufacture and the coiling from one tank to another, in order to ascertain the electrical values of the cable, as well as to detect, upon the shortest possible warning, the appearance of a fault.

A long and interesting description of a telegraph steamer (Fig. 1.) was next given by the lecturer, including the cable tanks (often 50 ft. in diameter and 25 ft. deep); the paying-out gear, dynamometer, etc.; and the picking-up gear at the bow, grappling rope, engines, drum, guide pulley, dynamometer, bow sheaves, etc. The ship being thoroughly equipped, found, and manned, ready to start on an expedition, a preliminary survey had to be made, a point very much neglected in the early days of submarine telegraphy, and now sadly repented. Carefully made surveys had brought to light many most valuable facts regarding the very varying character of the sea bottom, both near the land and in the depths of the ocean at great distances from the land. The irregularities of surface were often quite as great and as sudden as any on the mainland. Such an instrument as Sir William Thomson's large sounding machine, as also the one for taking soundings in shallow waters, were of immense value on board telegraph steamers; in fact, it was now found that they could not be dispensed with. Both of these valuable inventions were exhibited and described by the lecturer. In connection with Sir William Thomson's large sounding machine Mr. Jamieson devoted special attention to the sounding weight invented by Mr. Lucas, one of the chief telegraph engineers of the Telegraph

was enlarged upon, and with reference to the sixth cause, namely, lightning, the lecturer said that the remedy might be looked for in a good system of lightning guards and in carefully "earthing" the cable ends when an unusually severe thunderstorm occurs. Cases of interruption or fusing of a cable conductor were, fortunately, of infrequent occurrence, and he only knew of four well-authenticated instances.

When, from any cause, a submarine cable was broken, or became too faulty for the transmission of messages, a repairing ship, fitted with all the necessary appliances for grappling and lifting the cable, was dispatched with the least possible delay to the position localized by the electrician. But how to localize the position of a fault seemed to be a mystery unless to persons well acquainted with the laws of electricity, and, therefore, the lecturer gave an explanation of the *modus operandi*, which was eminently interesting. He started by reminding his audience how a carpenter or joiner, or any other person would proceed to measure the lecture table, and the units of length used for doing the work; and how the weight of any body, say, a piece of lead would be weighed in a pair of scales; and then proceeded to use those instances as analogies in the mode of determining the position of a fault in a cable. A person having got possession of a piece of telegraph cable, say, 100 miles, would if anxious to know what was termed its electrical resistance, apply to an electrician asking him to determine the number of units of resistance which it offered to the passage of an electrical current. The electrician would attach one end of the conductor of the cable to one side of his electric balance (see Fig. 3); put the other end of the cable to "earth," adding known resistances to the other side of the balance; and then he would inform the inquirer that the total resistance was 1,000 ohms, or 10 ohms per mile. The *ohm* was the electrician's unit of resistance, and was so called from the name of the person who first found out and demonstrated the laws relating to electrical resistance. The method by which an electrician set about finding out the resistance of the piece of cable was similar in many respects to that which would be employed by an ironmonger or other

person to determine the weight of the piece of lead, only a little more scientific, and perhaps at first difficult to understand. By the aid of a diagram and a Wheatstone bridge or balance, the explanation was made highly interesting. The "bridge" contained what might be regarded as the counterpart to the ironmonger's weights. They were known as resistance coils, and were made up of very fine and carefully adjusted platinum silver wires well insulated by being covered with silk, and wound upon bobbins, like ordinary thread bobbins. They were arranged from 1 ohm to 10,000 ohms, so that the electrician could measure the resistance of any conductor between those amounts with even or equal arms in his bridge. His detecter was Sir William Thomson's reflecting galvanometer, and occupied the place of the ordinary pointer in a common balance. The constant force of gravity assisted the operator in ascertaining the weight of the piece of lead in somewhat such a way as a constant electric force from a good battery helped the electrician to determine the resistance of the cable. When the electrician observed no current flowing through his galvanometer, the spot of light being perfectly steady at zero, he knew that he had got a balance, and he had then only to read off the resistance in circuit from the instrument referred to. That would be the resistance of a piece of cable, providing of course that the arms of the balance were equal. By way of applying these data to the localizing of a fault in a cable which had broken and would not transmit any more messages, Mr. Jamieson said that the electrician would be called in, that he would bring forth his inevitable balance and work it in exactly the same way. But he found that he only got, say, 300 ohms or units of resistance, while he observed the current to flow freely to "earth" without fluctuation, which was as much as to say that the fault or break was well exposed. He at once said to himself that when the cable was good and 100 miles long, he got 1,000 webers, or 10 webers per mile, and that he also knew it to be of uniform resistance throughout; he had, therefore, only to perform a very simple calculation, dividing 300 by 10, which gave 30 miles as the distance at which the fault occurred from the end operated upon. Proceeding as quickly as possible to the other end of the cable, the electrician, by the same mode of testing, found, say, a resistance of 700 ohms or units, which meant that the fault was 70 miles from that end. The distance having been carefully plotted off on a chart, and allowance being made for any "slack" that might have been paid out, a ship would be got ready with buoys, ropes, grapnel gear, etc., and would be dispatched with all due speed to the spot where the fault was believed to exist, or, as it was technically called, the "cable ground." The depth of water, and the nature of the bottom, together with a general idea of the nature of its configuration, would be determined by careful soundings. In making the soundings it was proper to ascertain if there were any tides or currents at the spot that might in any way affect the future operations of grappling and lifting. If no good landmarks were available for taking accurate bearings, a "mark buoy" would be placed when soundings had been obtained. The lecturer mentioned and described the different kinds of buoys that might be used for the purpose aimed at, and proceeded to notice the appliances that were in use as the grappling and picking-up gear, including the grapnel of his own invention. A small working model of this grapnel was used by the lecturer to demonstrate its capabilities in dragging for a piece of cable laid along a miniature sea bottom, extemporized out of a number of geological specimens, shells, sand, etc.; and another grapnel of the ordinary type was also shown in action, but found to be completely turned inside out, its prongs being found quite unequal to the work to be done. He explained that having caught, elevated, and brought the cable on board, the distance of the fault from the ship was determined by the electrician, the good side buoyed, and the other picked up to fault. The dynamometer now in use was also fully described, and some prominence was given to the scientific and practical operations had recourse to in jointing and splicing the cable after it was brought on deck, and the exact cause of the fault investigated. The operation of paying out the new cable was then commenced, and continued until the buoy attached to the other or good end was reached, when the buoy and its moorings, etc., and the cable attached, were lifted and brought on board. Both sides were now carefully tested, and if all right, a joint and splice were made between the two ends, and the bight carefully let go over the ship's side, tightening it as far as required before slipping.

In concluding his lecture, Mr. Jamieson remarked that he could not understand how it was that so very few of the "cable fleet," now numbering twenty-five fine steamers, had been built and equipped on the Clyde, and that no cable-laying machinery should ever have emanated from any place north of the Tweed. The engineers and shipbuilders of Glasgow should, he said, take example from their talented townsman, Sir William Thomson, who had not only invented, but designed, and made (by Mr. White of that city) the most perfect submarine telegraph instruments, without which long cables never would have paid; and he thought they should come forward and compete with Londoners and show the world that they could not only build the best cable ships, design and make the best machinery, but even construct the cable itself better and cheaper than the work could be done elsewhere.

DIVISION OF THE ELECTRIC LIGHT.

To the Editor of the Scientific American:

La Lumière Electrique has lately assumed a hostility to everything American, and especially to American electricians, that is unseemly in a journal of such high pretensions. In the last number (5th March, 1881) there is an article subscribed by F. Géraldy especially intended to vilify American inventors, and more particularly Messrs. Edison and Field.

In the same number, a correspondent, Mr. W. Tchikoleff, of St. Petersburg, claims priority of invention to our optical system of dividing the electric light, Patent No. 214,835, filed in July, 1878, and described in the SCIENTIFIC AMERICAN of 21st June, 1879; but so far forgets himself as to add:

"It is very possible that Messrs. Molera and Cebrian knew of my experiments in Russia (and I have reasons to believe so); but those estimable Americans have pushed their description enough to make it clear for me that they never made any experiments on this canalization."

Now, all and every one of such allegations are untrue; as we proved before the Commissioner of Patents in the interference case of Molera and Cebrian *vs.* De Castro, that we had conceived our invention in 1872, and that from 1873 to 1878 no less than five persons saw the drawings, descriptions, or experiments made by us of said system, and they gave testimony under oath of such facts. Whereas Mr.

Tchikoleff declares he never made any experiments before the fall of 1877.

We never heard of anything like our invention having been made until October, 1878, when the De Castro interference was declared and priority given to us. Much later we learned that Mr. Jaspar, in Belgium, Mr. Neale, in England, and some one in Russia, have also made similar inventions, though we anticipated all of them. As far as Mr. Tchikoleff's connection with this matter is concerned, we never heard of it until March, 1881, at the eleventh hour.

It is very extraordinary about *La Lumière Electrique*, that since the time our invention was published in your paper, it never believed in our system of distributing the light; but when some European claims to be the inventor, then it changes its mind, and says: "Although this system of lighting has been tried by Mr. Jaspar, in Belgium, to light his premises, and although a specimen thereof was presented at the Brussels Exhibition of 1880, yet it has not attracted the general attention, but according to Mr. Tchikoleff's communication, *it well deserves more serious consideration than what it has received.*" It is very possible that they have heard of experiments on a large scale made by us in Barcelona, Spain, and that on their success a company with half a million dollars already subscribed has been formed; and now they take the opportunity given them by Mr. Tchikoleff, to contradict their first assertions, and discredit American inventors, which seems to be their hobby.

MOLERA & CEBRIAN.

San Francisco, Cal., 13th April, 1881.

MERCADIER'S RESEARCHES ON THE PHOTOPHONE.

An elegant series of researches in photophony have lately been published by M. E. Mercadier, of Paris, who has very carefully examined the phenomenon discovered by Graham Bell and Sumner Tainter, that an intermittent beam of light may generate a musical tone when it falls upon a thin disk. By way of distinguishing this phenomenon and its applications from the phenomenon of sensibility to light exhibited by annealed selenium, which constitutes the essential principle of the articulating photophone, M. Mercadier adopts the name of *radiophony* for the subject of his research; a name which appears moreover to have the advantage of not assuming *à priori* what kind of radiations, luminous, calorific, or actinic, are concerned in the production of the phenomenon. It is agreed by all who have experimented in this direction that the pitch of the note emitted by the disk corresponds precisely with the frequency of the intermittent flashes of light; but it has been disputed whether the effect is due to light or to heat. Prof. Bell found that the beam filtered through alum water to absorb the calorific ultra-red rays produced tones; and that even when a disk of thin ebonite rubber was interposed, the beam robbed of both heat rays and light rays could still generate tones. On the other hand, from the list of substances given by the original discoverers, it was evident that since dark and opaque substances with dull surfaces, and those which, like zinc and antimony, have high coefficients of thermal expansion, produce, *cæteris paribus*, the best results, the effects must probably arise from heating effects due to absorption of radiations of *some* kind and their degradation into heat of low temperature.

M. Mercadier has summarized his results in an article in the *Comptes Rendus*, from which the substance of this article is translated freely. The chief conclusions are as follows:

I. *Radiophony does not appear to be an effect due to the vibration of the receiving disk vibrating transversely in one mass as in an ordinary vibrating elastic plate.*—This conclusion appears to be justified by the following observations: that, given a thin plate of any kind, under the conditions necessary for the production of the phenomenon, it produces equally well tones of all different degrees of pitch from the lowest audible up to the highest that can be generated experimentally by optical intermissions, and which in M. Mercadier's apparatus attained to a frequency of 700 vibrations per second. Moreover, it was found that these changes of pitch were accomplished without any defect in the continuity of the phenomenon; which would seem to indicate that it was not necessary for the plate to vibrate in any particular nodal or partial mode. Also the receiving disk will produce *chords* equally well in all possible tones from the highest to the lowest, the chord being complete no matter whether the fundamental pitch be raised or lowered by altering the speed of the rotating apparatus by which the intermittences are produced. M. Mercadier's apparatus consisted of a glass wheel carrying on its surface a paper disk pierced with four series of holes, numbering respectively 40, 50, 60, and 80. Through any one of these series of holes a small pencil of rays could be passed, and, by raising or depressing the axis of rotation of the wheel, could be sent successively through each of the four, thus producing, at any given rate of rotation, the separate tones of a common chord in succession; or by interposing a cylindrical lens to distribute the rays in a linear beam to the four series at once, the united tones of the chord could be produced simultaneously.

Further, it was found that the thickness and the breadth of the receiving disk make no difference within certain limits in the loudness or quality of the resulting tone. And in the case of transparent substances, such as mica and glass, these limits may be wide; in the case of glass the loudness was the same with a disk of half a millimeter as with one of three centimeters thickness. In consequence rare substances may be used in disks as small as one square centimeter in area. Cracked or split disks of glass, copper, and aluminum produce sensibly the same effects as if they were whole.

II. *The molecular structure and state of aggregation of the receiving disk appear to exercise no important influence upon the nature of the tones emitted.*—Disks of similar thickness and surface emit sounds of the same pitch no matter of what material they be. Although there may be slight specific differences between the actual modes of production of the phenomenon from *very* thin disks of different materials, these differences are reduced to a vanishing quantity by rendering the receptive surface alike, as, for example, by covering them all alike with a film of lampblack. Moreover, the effect produced by ordinary radiations is *cæteris paribus*, the same practically for transparent substances as widely differing from one another as glass, mica, selenite, Iceland-spar, and quartz, whether cut parallel or perpendicular to the optic axis, and is the same in polarized light as in ordinary light.

III. *The radiophonic sounds result from a direct action of radiations upon the receiving substances.*—This proposition appears to be established by the following facts: 1. That the loudness of the sounds is directly proportional to the quantity of rays that fall upon the disk. 2. That by using a polarized beam and taking as a receiving disk a thin slice of some substance which can itself polarize or analyze light, such as a slice of tourmaline, the resulting sounds exhibit variations of loudness corresponding to those of the rays themselves, when either polarizer or analyzer is turned; and the sound is loudest when the light transmitted by the analyzing disk is a minimum.

IV. *The phenomenon appears to be chiefly due to an action on the surface of the receiver.*—The loudness of the emitted sound depends very greatly upon the nature of the surface. Everything that tends to diminish the reflecting power, and increase the absorbing power of the surface, assists the production of the phenomenon. Surfaces that are rough ground or tarnished with a film of oxidation are therefore preferable. It is also advantageous to cover the receiving surface with black pulverulent deposits, bitumen black, platinum black, or best of all with lampblack; but the increase of sensitiveness under this treatment is only considerable in the case of very thin disks, as, for instance, from 0·1 to 0·2 of a millimeter. Very sensitive radiophonic receivers may be thus made with extremely thin disks of zinc, glass, or mica smoked at the surface. It may here be noted among M. Mercadier's results that for *opaque* disks, the thinner they are the louder is the sound, and that excellent results are given by metallic foil—copper, aluminum, platinum, and especially zinc—of but 0·05 millimeter thickness. The employment of such sensitive receivers has enabled M. Mercadier to arrive at several other important conclusions.

V. *Radiophonic effects are relatively very intense.*—They can be produced not merely with sunlight or electric light, but with the lime light, and also with gas light, and even with petroleum flames, and with a spiral of platinum wire heated in the Bunsen flame.

VI. *Radiophonic effects appear to be produced principally by radiations of great wave length, or those commonly regarded as calorific.*—In order to satisfy himself on this point M. Mercadier had recourse to the spectrum direct, without attempting to employ cells of absorbent material such as alum solution or iodine in dissolved bisulphide of carbon as ray filters. A brilliant beam of light was produced by means of a battery of fifty Bunsen cells, and with this, by means of ordinary lenses and a prism of glass, a spectrum was produced, the various regions of which could be explored with one of the sensitive receiving disks mentioned above. The maximum effect was found to be produced by the red rays and by the invisible ultra-red rays. From yellow up to violet, and beyond, no perceptible results were obtained. The experiment was tried several times with receivers of smoked glass, platinized platinum, and plain bare zinc. The greatest effect appeared to be yielded at the limit of the visible red rays. The rays which affect the electric conductivity of selenium in the photophone are, as Prof. W. G. Adams has shown, not the red rays, but rays from the yellow and green-yellow regions of the spectrum. This fact alone would justify the distinction drawn between the phenomena of radiophony and those of the selenium photophone, though probably these are only two of several ways of arriving at a solution of the problem of the transmission of sonorous vibrations by radiation. Theoretically a telephone with a blackened disk inclosed in a high vacuum and connected with an external telephone should serve as a receiver; and the writer of these lines has already attempted to devise a thermo-electric receiver for reproducing sounds from invisible calorific rays.—*S. P. T., in Nature.*

THE DENT CHRONOGRAPH.

One of the most important points in astronomical observations is to obtain an exact knowledge of the precise instant at which a phenomenon takes place. So in recent years, in proportion as instruments for observations have been made more and more accurate in their different parts, efforts have been made to attain greater precision in the instruments designed for giving time. Some few years ago the precision with which the moment of occurrence of a phenomenon could be noted did not exceed one-tenth of a second. The astronomer, in fact, having at his disposal only a pendulum beating seconds, took the hour when he desired, for example, the moment at which a star passed across the wire of the reticule of the meridian telescope, and afterwards counted the numbers of seconds beaten by the pendulum of the clock. It might happen, however, that the moment of passage occurred between two beats, and the observer was then obliged to estimate the interval which had passed between the last beat and the instant at which the star became hidden by one of the wires. With a little practice the time of a phenomenon could thus be inscribed to within about one-tenth of a second. But it must be remarked, that this fraction of a second, derived from a simple estimate, is subject to very many errors. Moreover, with this method of observation the astronomer must always, and often hastily, inscribe the result of his observation. To-day the precision with which the exact instant of a phenomenon may be noted is much greater, thanks to the *chronograph*, which itself writes the hours of the observations that may be afterwards read off at one's leisure, to one-fiftieth, and even to nearly one-hundredth of a second. The astronomer has nothing to do now but observe, as the chronograph, his faithful assistant, does the inscribing; he now no longer troubles himself with counting seconds, for at the desired moment this instrument notes, without the possibility of error, the exact moment of the observation.

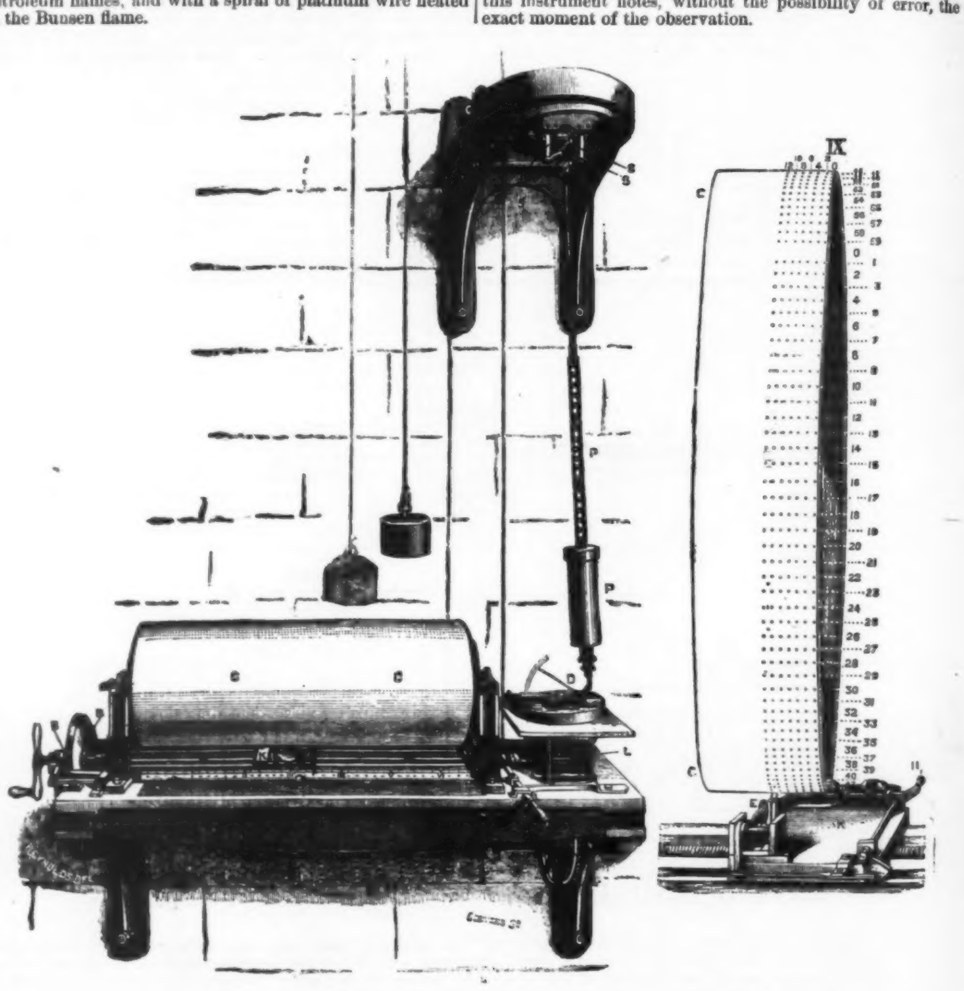


Fig. 1. Fig. 2.

Fig. 1.—THE DENT CHRONOGRAPH MOUNTED IN AN OBSERVATORY. Fig. 2.—DETAILS, ON A LARGER SCALE, OF A PART OF THE CYLINDER, CC, AND THE SCREW, WW.

Mr. E. Dent, of London, who has already made a reputation for clock-work of precision, has just finished three of these chronographs, which, for execution and exactness, are really *chefs d'œuvre*. One of these is designed for the Brussels Observatory, another has been ordered by the Japanese Government, and the third by the Khedive of Egypt.

Fig. 1 represents the apparatus as it is to be mounted in the observatory. C C is the drum on which is rolled the sheet of paper which is to receive the inscribed hours. Beneath this drum there is a screw, W W, which is rotated by the clock, L, and which communicates motion to the drum through the aid of cogwheels placed at the extremity of the drum and screw. The latter is encased in the lower part of the car, K, which runs on rails parallel to the screw, W W, while the latter is revolving on itself. The clock, L, is regulated by the pendulum, PP. The latter is a conical one, that is, instead of oscillating, it revolves about its point of suspension, S S, describing in so doing a cone. The car, K, carries two markers, one of which communicates with the regulating clock of the observatory. At every beat of the regulator (except at the sixtieth second of each minute), the marker rises and makes a point on the paper. The electric contact being established between the marker and the regulator, let us suppose the cylinder in motion; the car will slowly advance toward the left, and the marker will trace on the drum a series of points, which will be arranged in spirals slightly inclined toward one another and which will be separated from each other by intervals that correspond to one second. The minute will be indicated by the omission of the sixtieth point, which corresponds to the sixtieth

second. The car, K, carries a second marker located alongside of the first, and this is the one that inscribes the observation. When put in electric communication with the instrument that the astronomer makes use of, this marker can, at the desired moment and through the simple pressure of a spring by the observer, rise and mark a point on the paper of the cylinder (Fig. 2, and details in Fig. 3). The point thus marked will be somewhere along the spiral of the seconds points, and upon referring to these it will be easy to determine the precise instant of the observation to within nearly one-fiftieth of a second.

Let us now examine the points indicated on the drum (Fig. 2). The spiral of the seconds points runs around the cylinder from left to right. The drum makes one revolution in two minutes; and there is, then, between each point of one of the spirals and the point at the same height in the neighboring spiral a difference of two minutes. On referring to the figures in Fig. 2, placed at the top and side of

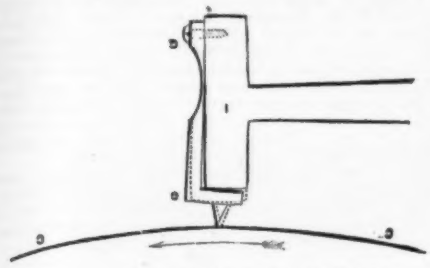


FIG. 3.—DETAILS OF THE MARKER.

the cylinder, it will be seen that the last seconds point corresponds to 9h. 12m. 46s. Let us now follow the spiral, in descending toward the marker; we find, first, the white line which indicates the beginning of the minute; then three observation points between the eighth and ninth second: one near the 22d second, another at the 24th, a third near the 25th, and finally a whole group near the 40th second. All these points will be set off and determined, after a little practice, to the one-fiftieth and even to near the one-hundredth of a second. All the observations having thus been carefully annotated, the sheet of paper is taken from the cylinder and put one side, so that it may be consulted in the future. It is not one of the least advantages of this chronographic method that it permits, in all doubtful cases and long afterwards, of recourse to the original observations. There is yet one arrangement to which we would call the reader's attention, and that is the pendulum regulator (shown in Fig. 4). U is a circular trough filled with a mixture of glycerine and water into which dips a pawl, D, jointed to the pendulum, P. When the motion of the latter accelerates, the pawl dips deeper into the liquid and the pendulum thereupon resumes its normal motion; but if, on the contrary, its speed slackens, the pawl rises and the motion is corrected.

FIG. 4.—PENDULUM REGULATOR.

Other improvements introduced by Mr. Dent have made his chronograph one of the most accurate ever devised. Thus, for instance, to avoid a sudden stoppage of the cylinder, a brake acts on the latter when the car reaches the end of its travel; and to prevent any injury to the regulator and to the clock movement when the drum stops, there is an arrangement which allows the pendulum to continue its motion and to come gradually to a state of rest.

DETERMINATION OF COLORS BY ROTATORY DISKS.

By A. ROSENSTIEHL.

THE author takes as his starting point a chromatic circle, drawn out on paper with seventy-two colors, the red, yellow, and blue being equidistant from each other, and the intervals filled with colors as equidistant as possible. Each color may be regarded as a mixture of two others, and the author has undertaken to measure the two components of each. Supposing the orange to be a mixture of red and yellow, the author makes a disk of two concentric circles, the smaller formed of two sectors, the one orange and the other blue. The larger circle consists of a red sector, a white sector, and an empty space representing the absence of light, and they are made to revolve rapidly. The blue sector extinguishes the yellow of the orange and forms white, while the red remains alone. The measure of the two resulting sensations is given by the angle of the red sector and that of the white sector. The author found 140° orange + 220° blue = 218° red + 56° white. In this manner the chromatic circle has been divided into four sections. The line which represents the proportion of the extreme sensations in the intermediate colors is straight. The line representing the sensation of yellowness reaches its culminating point on the ordinate corresponding to the yellow. In the other colors the case is different. The sensation of red goes on increasing in a straight line from the blue to the red, and continues ascending beyond without deviation as far as the orange, where it attains its culminating point. After this it lowers again as far as the yellow, where it is *nil*.

TELE-PHOTOGRAPHY.

A PAPER was lately read by Mr. Shelford Bidwell, before the Physical Society, "On the Telegraphic Transmission of Pictures of Natural Objects." The author was led to the idea from experiments which he had made on the photophone. The principle of the arrangement is that of the Bakewell or D'Arlincourt copying telegraph, in which the variations of the current necessary to produce the design are effected by the action of light on a selenium cell. In the copying telegraphs referred to, the design is traced out in a series of broken lines of uniform thickness; in Mr. Bidwell's arrangement the varying force of a current produces a corresponding variation in the definition of the lines on the chemically prepared paper, and thereby a more faithful representation of the object copied is produced. The experiments made as

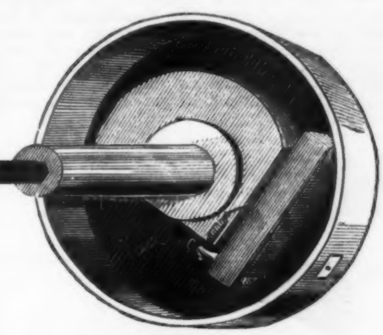


FIG. 1.

yet have been only comparatively rough ones, yet the amount of success obtained was considerable, and would seem to prove that with more perfect apparatus very satisfactory results could be attained.

In the first experiments it was proved that the variation in the resistance of the selenium cell, due to the action of light, could produce distinct changes in the marks on chemically prepared paper. In consequence of the satisfactory results, the apparatus, of which we give an illustration, and for which we are indebted to Mr. Bidwell, was devised.

The transmitting instrument consists of a cylindrical brass box (Fig. 1) four inches in diameter and two inches deep, mounted axially upon a brass spindle seven inches long, and insulated from it by boxwood rings. The spindle is divided in the middle, its two halves being rigidly connected together by an insulating joint of boxwood. One of the projecting ends of the spindle has a screw cut upon it of sixty-four threads to the inch; the other end is left plain. The spindle revolves in two brass bearings, the distance between which is equal to twice the length of the cylinder; and one of the bearings has an inside screw corresponding to that upon the spindle. At a point midway between the two ends of the cylinder a hole, H (Fig 2), a quarter of an inch in diameter, is drilled, and behind this hole is fixed a selenium cell (Figs. 3 and 4), the two terminals of which are connected respectively with the two halves of the spindle. The bearings in which the spindle turns are joined by copper wires to two binding screws on the stand of the instrument. This transmitter is represented in general view by Fig. 1, and in diagram in Fig. 5, where H is the hole in the cylinder opposite the selenium cell.

The receiving instrument contains another cylinder similar to that of the transmitter, and mounted upon a similar spindle, which however is not divided nor insulated from the cylinder. An upright pillar, D, (Figs. 2 and 5), fixed midway between the two bearings, and slightly higher than the cylinder, carries an elastic brass arm fitted with a platinum point, P, which presses normally upon the surface of the cylinder. To the brass arm a binding screw is attached, and a second binding screw in the stand is joined by a wire to one of the brass bearings.

To prepare the instruments for work they are joined up as shown in Figs. 2 and 5, two batteries, B, B_1, a set of resistance coils, R, and a galvanometer, G, being used. The cylinder of the transmitting instrument is brought to its middle position, and a picture not more than two inches square is focused upon its surface by the lens, L (Fig. 5). The pictures upon which the author operated have been mostly simple geometrical designs cut out of tin foil and projected by a magic lantern. The comparatively large opening, H, is covered with a piece of tin foil, in which is pricked a hole, which should be only just large enough to allow the instrument to work. The hole is then brought, by turning round the cylinder, to the brightest point of the picture, and a scrap of sensitized paper, in the same condition as that to be used,

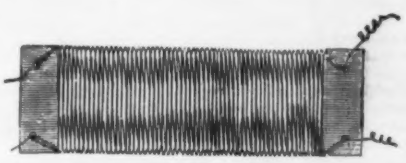


Fig. 4.—Mica Plate, wound with Two Copper Wires ready for Selenium Coating.

being placed under the point, P, of the receiver, the resistance, R, is adjusted so as to bring the galvanometer to zero. When this is accomplished, the two cylinders are screwed back as far as they will go, the cylinder of the receiver is covered with sensitized paper, and all is ready to commence operations.

The two cylinders are caused to rotate slowly and synchronously. The pin-hole at H in the course of its spiral path will cover successively every point of the picture focused upon the cylinder, and the amount of light falling at any moment upon the selenium cell will be proportional to the illumination of that particular spot of the projected picture which for the time being is occupied by the pinhole. During the greater part of each revolution the point, P, will trace a uniform brown line; but when H happens to be passing over a bright part of the picture this line is enfeebled or broken. The spiral traced by the point is so close as to produce at a little distance the appearance of a uniformly colored surface, and the breaks in the continuity of the line constitute a picture which, if the instrument were perfect, would be a monochromatic counterpart of that projected upon the transmitter.

An example of the performance of the instrument is shown in Fig. 7, which is a very accurate representation of the manner in which a stencil of the form of Fig. 6 is reproduced when projected by a lantern upon the transmitter. In order to render the paper sufficiently sensitive, it must be prepared with a very strong solution (equal parts of iodide and water), and when this is used the brown marks disappear completely in less than two hours after their formation. There is little doubt that a solution might be discovered

Fig. 3.—Selenium Cell.

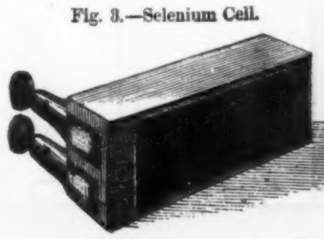


Fig. 2.

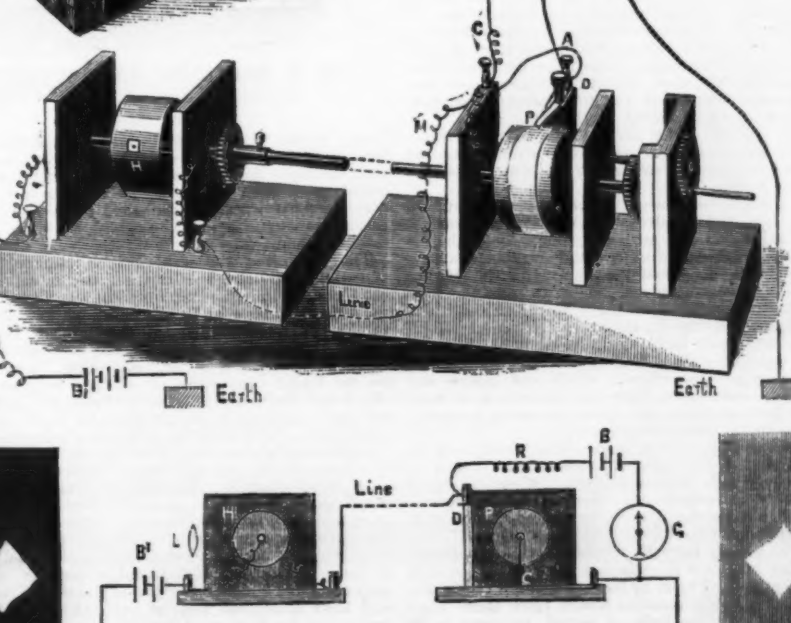


Fig. 6.—Image focused upon Transmitter.

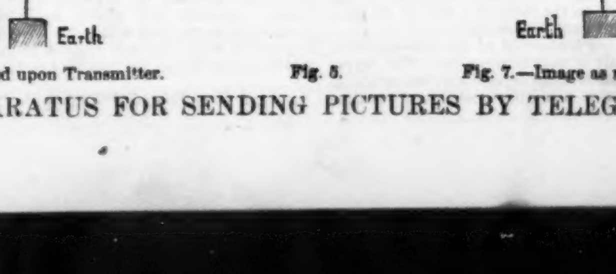


Fig. 5.

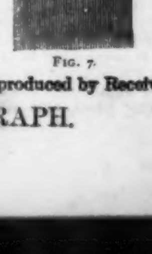


FIG. 7.

Fig. 7.—Image as reproduced by Receiver.

APPARATUS FOR SENDING PICTURES BY TELEGRAPH.

which would give permanent results with equal or even greater sensitiveness, and it seems reasonable to suppose that some of the unstable compounds used in photography might be found suitable.

Although in the apparatus shown by Fig. 2 the transmitter and receiver are connected mechanically together, they can, of course, be joined electrically, as in D'Arlincourt's apparatus.

HYDROPHOBIA FIVE YEARS AFTER INOCULATION.

M. COLIN has related to the Academy of Medicine a remarkable instance of prolonged incubation of hydrophobia. The man died, after a sickness of two days, with all the symptoms of hydrophobia. Autopsy revealed no lesion whatever; but there were some small scars discovered on the wrist and chest. The man's history showed that he had been undoubtedly bitten by a mad dog five years before. Supposing it true, the ideas suggested by some of M. Pasteur's recent experiments might be brought into use. He found that in chronic cases of fowl cholera the poison remained in some of the organs of the body. It did not enter into the general system until by some accident it was led to a rapid development and escape into the blood. Death then followed at once.

ON THE LAW OF AVOGADRO AND AMPERE.

IN an article published in the SCIENTIFIC AMERICAN SUPPLEMENT, April 16, 1881, Mr. Edward Vogel claims that he has completely demolished the hypothesis of Avogadro and the theories of modern chemistry. His arguments are, however, based upon entirely erroneous premises, and carry with them no weight.

He states that "cyanogen is a gaseous compound, the molecule of which, CN, is, according to the hypothesis, composed of 1 carbon and 1 nitrogen atom; it is neither assumed nor maintained that the molecules contained in 1 vol. CN=26, have the molecular weight 52. . . . When it combines with another body substitution is not possible." And because cyanogen combines with hydrogen or with chlorine without diminution of the total volume, he draws "this inevitable conclusion," that "the whole theoretical structure, built on Avogadro's hypothesis, falls to the ground."

Mr. Vogel then proceeds to demolish J. Clerk Maxwell's conclusion from mathematical reasoning, that equal volumes of gases are chemically equivalent.

In the first place, it is not pretended by chemists that the molecule of cyanogen, or any other body, occupies one volume; but if the atom of hydrogen occupy one volume, the molecules of gaseous bodies, simple and compound, will occupy two volumes. The molecule of cyanogen is $(CN)^2$; the specific gravity of the free gas (1·801) corresponds perfectly with the law of Avogadro, indicating that the molecular weight of cyanogen is 52, one atom of hydrogen weighing 1. When cyanogen combines with chlorine, there is naturally no condensation, for the theory is fulfilled by the actual reaction.

$(CN)^2$	+	Cl^2	=	CNCl	+	CNCl
1 molecule.		1 molecule.		1 molecule.		1 molecule.
2 vls. wgt. 52.		2 vls. wgt. 71.		2 vls. wgt. 61·5.		2 vls. w. 61·5.

No better example could be given to show the compound nature of free chlorine; no better example of substitution in direct combination.

Mr. Vogel, as all opponents of the atomic theory have done, refers to the vapor density of ammonium chloride (14·43 at 350°). "This density is near the boiling point; to assume that the vapor is then decomposed into a mixture of its constituents is to assume that decomposition does not take place gradually with rise of temperature as in other cases, but is complete at a temperature near the boiling point."

From the development of heat produced by the mixture of NH^3 with HCl at 360°, H. Sainte Claire Deville concluded that the vapor of ammonium chloride, which occupies nearly four volumes at that temperature, is not a mixture of the two gases. This development of heat is inconsiderable. The observed density, 14·64, is greater than that which the vapor should possess did it occupy four volumes (13·375). We must, therefore, conclude that a part of the salt (16 per cent.) is volatilized, occupying two volumes, while the remaining 84 per cent. is dissociated, occupying four volumes. The experiments of Marignac, on the heat of volatilization of ammonium chloride, confirm this view, for it was found that the heat required to volatilize a given weight of the salt is very little below that which is produced by the combination of NH^3 and HCl, and which should consequently become latent in the dissociation. It is, therefore, extremely probable that ammonium chloride is almost entirely dissociated, even at the temperature of volatilization. Horstman has reached the same conclusion from other experiments, and, more recently, Böttinger has contrived an apparatus by which the actual dissociation may be shown as a lecture experiment.

Ammonium chloride is no exceptional body in its dissociation at the temperature of volatilization; calomel and chloral hydrate are common substances which are dissociated at their boiling points.

Mr. Vogel seems to have forgotten or to have ignored the fact that the law of Avogadro and Ampere refers only to gases, for he states that one inevitable conclusion of the law would be "that combination of compounds results always in condensation to 2 vols., whatever the sum of the volumes of the combining constituents may be." He, therefore, concludes that, the density of liquid HCl being 1·27, and that of liquid NH^3 being 0·6234 (?), the density of liquid NH^4Cl should be 1·8934, which is greater than that of the same substance in the solid state. Whatever relations may exist between the physical properties of solids and liquids and their molecular composition, such relations can in no manner affect the laws of gases, and their discussion is wholly foreign to the matter under consideration.

The conclusion of the article is somewhat presumptuous. "From all that has been said, it follows that Avogadro's hypothesis is absolutely without support. What will be the consequences of its overthrow? Very few considerations will show that not only will there be no loss to chemistry, but a wonderful simplification and harmony of facts."

It would be useless here to furnish facts in support of Avogadro's law; suffice it to state that half-a-dozen apparent discrepancies are seized upon by the opponents of the theory, who will listen to no explanations which place these apparent discrepancies in the light of actual supports to the theory, and which raise it to the rank of a law, if we may use the word law with reference to molecules.

It is impossible to at once foresee all of the consequences of a truth, however firmly it may impress us. The hypothesis of Avogadro was based upon certain known facts concerning gases, and attracted but little attention at the time of its enunciation, in an imperfect form, by Ampere. It has been found to harmonize so well with other facts which have since been discovered, and the apparent exceptions have so completely disappeared, that we now regard it as a law. We can no more prove its truth than we can prove the existence of atoms themselves; but the atomic theory, the theory of Avogadro, and the theory of atomicity, have formed a chain, linking together all of the known facts of chemistry. They have done more; besides affording an intelligible explanation of chemical actions, they have enabled the prediction of thousands of reactions which would have remained undiscovered without the aid of theoretical prophecy. We cannot insist on their absolute truth, but they are accepted by ninety-nine out of every hundred chemists, and their serious study is leading every day to their further development. Chemists no longer work in the dark, as was too often the case before the light of the atomic and molecular theories had been furnished, and they would be unwilling to abandon this light without the substitution of a better.

True it is that a chemist may work on original and independent hypothesis, but his results would be as unintelligible to others, as if each author were to invent a language for himself and require that others should find the key in order to understand his thoughts. The modern theories of chemistry have furnished a universal key by which the reasoning of one chemist is made accessible and tangible to all others.

For the hypothesis of Avogadro, and the structures erected on that basis, all of which Mr. Vogel claims to have overthrown, he substitutes nothing whatever; but, according to his idea, it is the weight of that volume of any gaseous element which combines with one atom of hydrogen, which should be taken as the atomic weight of the element. Thus the atomic weight of nitrogen, according to Vogel, would be $\frac{14}{3}$=4·66, that of phosphorus $\frac{31}{3}$=10·33. But aside from the fact that such atomic weights would be more arbitrary than any which have heretofore been suggested, what then would become of the law of specific heats? What would be indicated by isomorphism? And yet in his very article, Mr. Vogel accepts the proposition that the atomic weights are inversely as the specific heats.

The words *atom* and *molecule* have become the symbols of certain well-defined existences, and these existences do not blend, so that the one word may signify the other, but the differences between them are well marked, and no chemist thinks of confounding the two terms. Yet Mr. Vogel would consider the words atom and molecule as synonyms for "combining weight" or "equivalent," which he thinks are the fitting expressions of his new numbers. In this, Mr. Vogel is attempting what Berthelot and his few followers have vainly been endeavoring, for nearly a quarter of a century, to hold back, the progress of scientific chemistry, —mathematical chemistry, if one choose so to call it—which has advanced beyond the stage of a recreation, and has become, as all scientific study must be, a matter of work. But Mr. Vogel can not claim, as can Mr. Berthelot, any real work or experiment, however roughly performed, suggested by the desire to prove the truth of his own views. Let him not then bring forth old, and long since explained discrepancies to the generally accepted chemical theories, although he may not have encountered the explanations; but when he will have discovered new or overlooked facts, which will overthrow the law of Avogadro, or any other chemical theory, chemists will gladly hail the event as one step toward the truth, and will quite as gladly listen to any new hypothesis which he may suggest to take the place of that which can no longer be regarded as true.

WM. H. GREENE.

Central High School, Philadelphia, 17th April, 1881.

THE PURIFICATION AND SOFTENING OF WATER.

MESSRS. F. ATKINS & Co., of London, have long engaged themselves on this subject, and the peculiarity of their system is the employment of a filter so made that the cloths by which the filtration is effected can be occasionally cleaned of that which they have separated from the water, by means of brushes so manipulated as to make it unnecessary to take any part of the filter asunder.

We now propose to describe the combination of the Clark's process with filter press filtration as carried out by Mr. J. H. Porter. At the Banstead Asylum, as is well known, there are some miles of hot water pipes for heating the building. This heating apparatus was arranged and executed under the instructions of Mr. F. J. Bramwell, and the advantage of having softened water so that no deposit of carbonates and sulphates, lime and magnesia should take place in them, was the inducement to try the system of softening and filtration devised by Mr. Porter. After trial on a small or temporary scale the system was adopted, as described by Mr. Bramwell before the British Association, at Plymouth, in August, 1877. Since that time the arrangement of apparatus necessary for the combined processes has been largely adopted in manufactories, in private and public buildings, and for town water supply, and even more largely for the softening and purification of water for steam boilers, fixed and locomotive, in order to prevent incrustation and consequent loss of efficiency, economy in fuel, and unnecessary wear of boilers.

In clear waters from wells or springs of the chalk formations the hardness is produced almost entirely by carbonate of lime. Where carbonates of magnesia and of iron are present in any considerable proportion, the time necessary

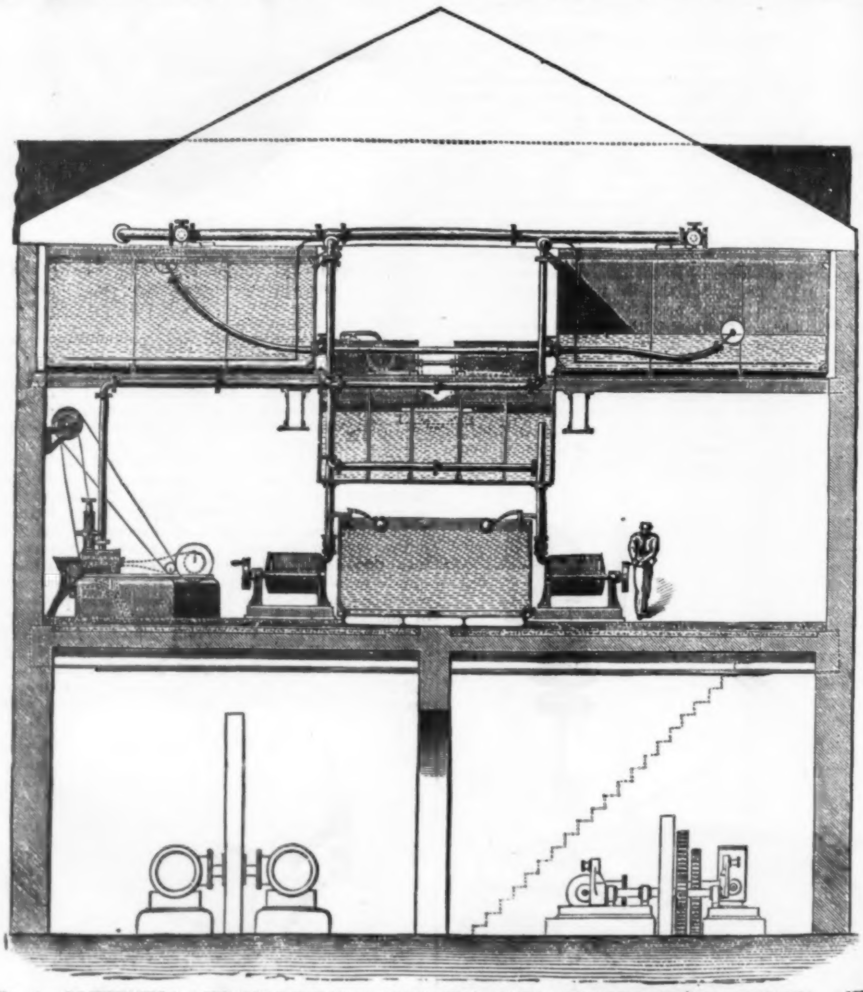


Fig. 1.—SOFTENING AND FILTERING APPARATUS, INDIA-RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS, SILVERTOWN.

for chemical action is greater, and necessitates more extensive plant. Water from the chalk underlying the London clay and in the vicinity of the river is very variable in character, and may—like pond and river waters containing organic matter and some alumina—require special treatment, involving greater expense in the plant and in the working.

In dyeing operations the sulphates are not considered to seriously affect the colors; it is the bicarbonate of lime, both in dyeing and in the steam boiler, that occasions so much embarrassment and so much waste. By means of additional reagents, the sulphates of lime, etc., may, moreover, be removed, where their presence is seriously objectionable; but while, in boiling continuously under considerable pressure, a proportion of these sulphates may crystallize out as the solution becomes concentrated, occasional blowing out of the boiler will get rid of the concentrated solution. In the earlier works carried out by Mr. Porter, open vessels or tanks were employed, but more recently he has made some improvements, economizing cost and space, and securing simplicity of working, by making use of closed cylindrical vessels. The two systems are illustrated by Figs. 1, 2, 3, 4, and 5. In Fig. 1 is given a sectional view of the plant in operation at the works of the Silvertown India-rubber, Gutta Percha, and Telegraph Works Company. A vertical line through the center of Fig. 1 would give, on either side, a representation of the arrangement at the paper mills of Mr. Edward Lloyd, at Sittingbourne, the apparatus there treating 6,000 gallons per hour. Figs. 2 and 3 show the plant in operation at the locomotive sheds of the London and Northwestern Railway Company in Liverpool. At Silvertown 12,000 and at Liverpool 15,000 gallons of water are treated per hour continuously, or over a ton per minute. In each case the supply of hard water comes to the softening apparatus from a tank above, into which it is continually pumped from a well.

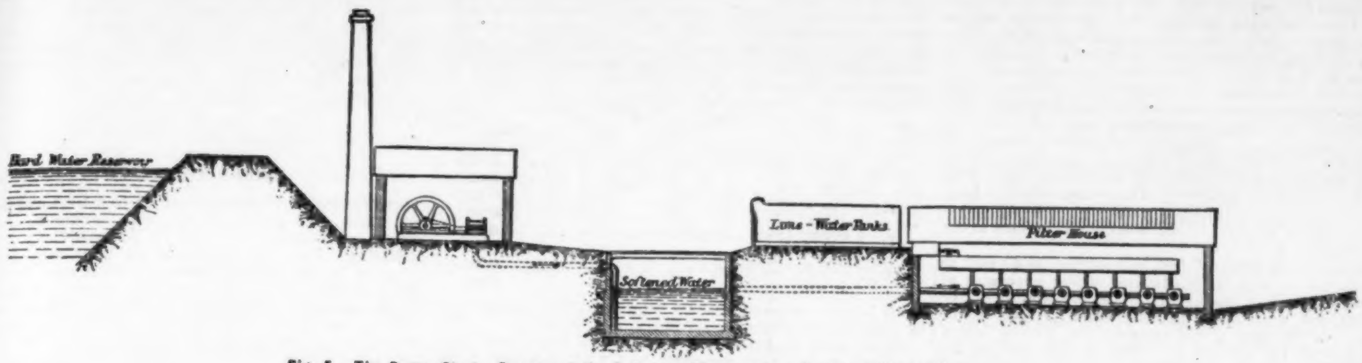


Fig. 5.—The Porter-Clark Process at the Swindon Waterworks.—Sectional View of Works.

Figs. 2 and 3.—Front Elevation and Longitudinal Elevation of Apparatus at Edge Hill, Liverpool.

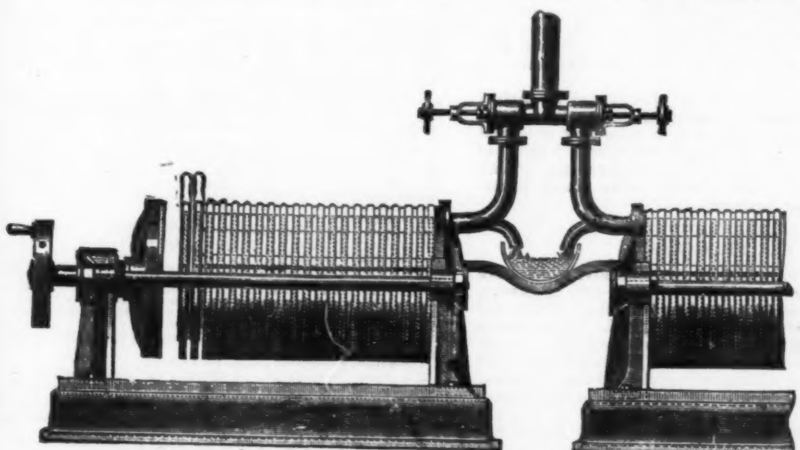


Fig. 6.—Arrangement of Filters at Liverpool.

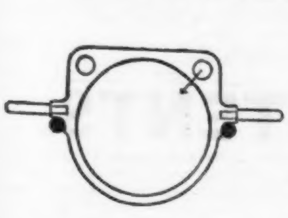


Fig. 7.—Water-space Frame.

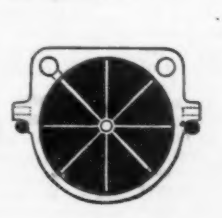


Fig. 8.—Filtering Plate or Chamber.

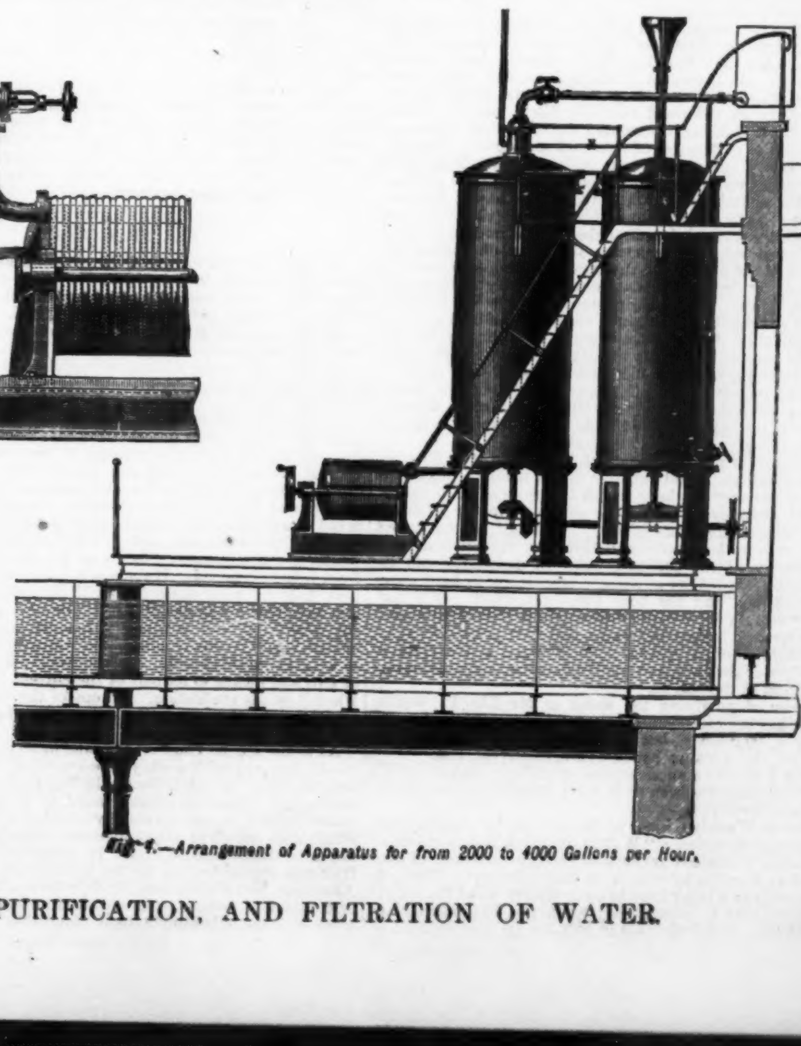


Fig. 4.—Arrangement of Apparatus for from 2000 to 4000 Gallons per Hour.

PLANT FOR THE SOFTENING, PURIFICATION, AND FILTRATION OF WATER.

The pair of tanks shown, right and left, in Fig. 1, showing the Silvertown apparatus, are 29 feet in length by 13½ feet in width, and contain each eight hours' supply of lime-water. This lime-water is used in a clear state, and, as nearly as may be, fully "saturated;" therefore, while one is in course of being emptied, the other is filled, the excess of lime kept in it is roused up by revolving machinery; and then, the machinery being stopped, the excess of lime slowly settles, leaving strong clear lime-water ready for use. The more recently devised apparatus dispenses with the previously necessary large tanks, and employs instead, as is shown in Fig 2, vertical cylindrical tanks containing a horizontal or vertical slowly-revolving spindle fitted with a simple form of rouser or agitating arms, which serve to keep the water in the tank in sufficient motion to cause the necessary agitation and mixture of the water with the lime at the bottom of the tank.

Of the pair of cylinders, 7 feet in diameter by 30 feet in height, shown in Fig. 2, illustrative of the apparatus at Liverpool, one only is employed for the preparation of the lime-water, and contains a quantity equal to four hours' working only, as against the capacity for sixteen hours' working provided at Silvertown. But in this case, by the adoption of the constant circulation, and a constant but very slow revolution of the rousing machinery at the bottom of the vessel, the water entering among the lime at the bottom becomes saturated, and, as it slowly ascends by the current induced by the outlet pipe, shown at the top, parts with the excess of lime in suspension, and becomes cleared in doing so. The softening of the hard water, by the continuous admixture of about 10 per cent. of this lime-water from this cylinder with it, is carried on at Liverpool in the second cylinder, and at Silvertown in an open tank between the two lime-water tanks. Thus, the whole of the water passes through this tank.

To promote the chemical action of the lime-water upon that proportion of the carbonic acid of the hard water that holds the carbonates in solution, a brisk agitation is kept up in the mixing vessels. At Silvertown this is done by forcing in air through perforated pipes, by means of a steam air pump; and at Liverpool the agitation is produced by sets of revolving grids driven by a small steam engine.

As the chemical action of the clear lime water takes effect upon the carbonic acid in the clear hard water, infinitely minute crystals of carbonate of lime are produced, rendering the water chalky and of a milky appearance. This chalky water descends at Silvertown direct to the four filter presses ranged on either side of the softened water tank; at Liverpool it is led over by a 12 in. pipe into the filtering room, where it is connected with a horizontal cylinder 2 ft. 9 in. in diameter; whence, as at Silvertown, the chalky water descends to the four pairs of filtering machines—see Figs. 3 and 6.

Fig. 6 illustrates a pair of these filters at Liverpool. They contain each 100 square feet of filtering surface, and five of them are sufficient to be in action at one time for the 15,000 gallons per hour. At Silvertown, where the water is less pure, and the head of pressure also less, a larger proportionate filtering area is required for the quantity of water treated. Each filter is made up of a series of cast iron plates and cast iron open frames of the form shown by Figs. 7 and 8.

Over these filtering chambers, of about 1 in. in thickness, is dropped—as a towel placed upon a towel horse—a cloth of fine cotten twill, having holes worked in it to correspond with the holes through the upper corners of both water space frames and filtering chambers. When these alternate water spaces and filtering chambers with cloths are pressed closely and tightly together by a powerful end-screw, it will be seen that the holes become, collectively, tubular channels of the length of the "battery," the channel of the one side admitting its chalky water to the circular water spaces, whence, being inclosed and under pressure, it can only escape through the adjoining cloths into the concentric and radiating grooves which conduct it by a small outlet to the channel on the other side.

The frequency with which it may be necessary to change the cloths depends upon the amount and character of the impurity, other than the chemically formed chalk, present in the water. At Liverpool, Sittingbourne, and other places where the waters are from deep wells in the chalk, or red sandstone, we are informed that the filters run for fifteen hours before it is thought necessary to remove the cloths and their deposit of carbonates of lime and magnesia. This deposit is easily removed by an ordinary trowel or by a wooden blade, and in the other modifications of the apparatus Mr. Porter intends to attach the cloths to the filtering chambers so as to admit of their being thus partially freed from deposit without being disturbed, and a reverse current of the filtered water is to perform the office of freeing the interstices of the cloth from the crystalline mass of carbonate of lime, or from the compacted impurity they would otherwise retain. The labor of one man, however, is found sufficient at Edge Hill to cleanse cloths and filters and attend to the other details of the process in softening 150,000 to 180,000 gallons for the day's work, so that the time occupied in removing and cleaning filter cloths does not seem to be of great importance in all cases. At Silvertown, where the character of the water gives a slimy and viscous deposit, a lad assists the workman, and their united wages amount to 0·62 of a penny per thousand gallons.

The deposit of pure carbonate of lime from the filters is, in some instances, found valuable in the manufactures carried on at the very works in which the process is in operation, and, as for every ton of lime employed in the softening process about three tons of this "whiting," of the purest quality, results, the process will often cost very little indeed. The influence of the softened water in dislodging old incrustations from boilers previously working with hard water is very curious, and has been often remarked. It is particularly noticeable with the locomotive boilers at Liverpool, as in stationary boilers elsewhere, and the principal object of the adoption of the system in these cases is the employment of water that will leave no calcareous, non-conducting incrustation in the boilers.

The cost of purifying the water at Mr. Lloyd's works, where it has been in operation for two years, is found to be 1d. per 1,000 gallons, but in treating very much larger quantities, the working expenses are, relatively, less.

In Fig. 4 is shown an arrangement of the apparatus which in different sizes has been or is being fitted in several waterworks and breweries.

Professor Wanklyn wrote of the process by precipitation without any filtration: "Waters to which this method of purification is adapted are such as contain carbonate of lime retained in solution by excess of carbonic acid. The process consists in adding lime to such waters until the excess of carbonic acid is neutralized; when this has taken place both the lime added and that in solution are precipitated as carbonate, a minute quantity remaining in solution, as carbonate of lime is not absolutely insoluble in water. By this process not only is the water softened, but a very large proportion of the organic matter contained in it is removed, and if the water be colored, the coloring matter is also entirely or in very great part removed. The following examples will indicate to what extent the organic matter is removed by this process:

Parts per 1,000,000.

		Free. NH_3.	Albuminoid. NH_3.
I.	Before Clark's process	0·01	0·05
	After " "	0·01	0·02
II.	Before Clark's process	0·025	0·22
	After " "	0·030	0·08
III.	Before Clark's process	0·015	0·22
	After " "	0·020	0·07
IV.	Before Clark's process	0·105	0·12
	After " "	0·15	0·06

"It is to be observed, that the organic matter removed can be proved to be present in the chalk precipitated."

Of the hardening salts present in potable water, carbonate of lime is the one most generally met with, and the above table gives a good idea of the effectiveness of the process in removing this. To obtain a numerical expression for this quality of hardness, a sample containing 1 lb. of carbonate of lime, or its equivalent in other hardening salts, in 100,000 lb., is said to have 1 degree of hardness. Each degree of hardness indicates the destruction and waste of 12 lb. of the best hard soap by 100,000 lb., or 10,000 gallons of the water when used in washing. Thus 10 gallons of water of the hardness of Thames water cause the waste of nearly a quarter of a pound of soap when it is used for washing, and yet the water may be softened and filtered at a cost of less than 1d. per 1,000 gallons. It is, however, estimated that upon the scale of operations involved in the treatment of the London river water supply of 125 millions of gallons, the cost would be reduced to one-third or one-fourth of a penny per 1,000 gallons. Considering that the householder of London pays, for very hard water not perfectly filtered, fully 2s. per 1,000 gallons, the working expense of even 1d. per 1,000 gallons will hardly appear to the consumer as a sum to be caviled at. To one paying £4 4s. per annum for say 100 gallons consumed daily, or 36,500 gallons in the year, 36½d. would be an insignificant addition to pay for soft, purified, and brilliantly clear water.

In 1877 the directors of the Swindon Waterworks Company had to consider the best system for purifying and partially softening the water supply of Old and New Swindon; and, after studying the various systems in operation—visiting among others the older works at Canterbury, and the examples of the process in operation at the works of Mr. Duncan, in London, and at the New Middlesex County Asylum, at Banstead, in Surrey, they gave the preference to the system adopted by Mr. Porter.

The water supply of the towns of Old and New Swindon is collected chiefly from springs in the greensand thrown out by the gault at Wroughton. The spring water is of about 34 degrees of hardness, in parts, per 100,000, or about 24 degrees, in grains, per gallon; but the reservoir being formed by an embankment at the foot of a long and wooded ravine, the degree of hardness is more or less modified by a varying quantity of surface water, which contributes also varying quantities of organic matter, chiefly of vegetable origin, together with earthy matter or alumina.

The illustration, Fig. 5, shows a sectional view of the plant employed at Wroughton for the water supply of Swindon. A pair of wrought iron tanks, each 30 ft. by 15 ft. by 8 ft. in depth, serve for the preparation of the lime water, a due proportion of which is led into one compartment of the smaller cistern, placed above one end of the long tank—50 ft. in length—in the room at the lower level. Into another compartment of the same cistern, the water flows, by gravitation, from the reservoir on the higher ground. Valves actuated by levers, to which motion is given by a large float in the long tank beneath, allow the two waters to fall into this "mixing tank," in which a violent agitation is kept up by air continually forced in through perforated pipes.

To give the more time for the chemical action to perfect itself, the water is compelled, by partitions, to flow down the two sides of the long tank, and to return by a central compartment—closed at the upper end—from which, as under a similar arrangement at Silvertown, the chalky water descends to the eight double filters placed immediately beneath.—*The Engineer.*

SEA SICKNESS.

ALL the remedies for this distressing malady, which have come to my notice in your valuable paper and elsewhere, have been either medical, or else mechanical devices for keeping the ships' berths or staterooms level. While motion is one of the causes it is doubtful if more than two to four-tenths of the trouble is due to it. With large ships and moderate weather the movement is slight and near the center of the vessel, perhaps almost null, yet few passengers escape sickness.

The main causes of sea sickness are, no doubt, foul air and improper food. In evidence of the first assertion is the fact that, getting on deck into pure air, is the one remedy universally and always prescribed; sick or well you rise early, dress in the quickest possible time and manner, and get on deck to stay there until late at night. On many ships there is but one small cabin on deck, monopolized perhaps by the smokers, yet even the ladies will sit out in all sorts of weather, and refuse to go below as long as they can keep from being drenched. If the sea is quite smooth the small port hole in your stateroom will be opened a few hours; whether fresh air comes in depends on the wind; in doubtful weather it will not, and you must bear it. Wet bed clothes dry very slowly at sea, and the steward finds it easier to keep the ports closed. The remedy is plain; a fan blower or two and means to let part of the current into your room when it wants ventilating. On one of the largest and best passenger ships the air in the steerage was found to be much better than in the staterooms.

As to the second cause: it is found more profitable to carry meats than vegetables—they take less room on the ice, etc.—and the supply of the latter, including fresh fruit, is always inadequate. Passengers condemned to a life of inactivity and breathing sea air are usually attacked with constipation, which does not yield to any moderate remedy, and, perhaps, not until the voyage is over. In addition to the lack of fruit and vegetables, the service is foreign, it is cheaper than American, and the cooking is, therefore, after the English or continental fashion, rich with lard and spices, and even when sick the only simple food obtainable is the morning allowance of oatmeal gruel, and the only water free from the taste of the ship is that from ice melted in your mouth.

It is useless to propose remedies which do not touch the real causes. Let radical Americans take hold of the matter and give us ships in which human beings can be carried safely, and are provided with pure air and wholesome food—everything American-like, adapted to the conditions—and American ships will carry the paying passengers in spite of the reputations of foreign lines conducted on the present system.

J. BURRITT WEB[illegible]

EARLY DENTISTRY.

SIR GARDINER WILKINSON affirms that teeth stopped with gold have been found in Egyptian mummies, and other learned gentlemen hold vigorously that the thing is an impossibility. Dr. John Gaigor, in the interesting discussion going on in the *British Medical Journal*, says that in the Etruscan Museum of Corneto, the ancient Tarquinia of Etruria, and a few hours distance from Rome, he has seen teeth in a skull bound together by threads of gold cleverly twisted in and out among them; and that he has seen the same thing in museums in the Vatican and elsewhere. From these facts he presumes that it is quite probable the ancient Egyptians had more or less skillful dentists. His deduction is supported by a gentleman who is positive that he once saw in the Meyer Museum, in Liverpool, the jawbone of a mummified Egyptian in which a number of teeth were secured by a golden wire. It is also claimed that the Hindoos, 600 years ago, knew something about the art of binding together teeth that were disposed to abandon each other's company. Mr. Briggs, in his "Rise and Fall of the Mohammedan Power in India," describes a battle in which Kootub-ood-Din, the famous general of Mohammed Ghory, who built the Kootub, a tower which rises near Delhi to a height that makes it one of the most beautiful wonders of the world, slew with an arrow a powerful rajah, whose corpse was afterward identified, according to the writings of Ferishta, by his artificial teeth, which were bound together by wires of gold.

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